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Cropping Systems for Treatment and Utilization of Municipal Wastewater and Sludge

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Michigan State University
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CROPPING SYSTEMS FOR TREATMENT AND UTILIZATION OF MUNICIPAL WASTEWATER AND SLUDGE

by

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16. ABSTRACT
The efficiency of nitrogen stripping by intercropping forages with corn is evaluated in a three-year study at Muskegon County Wastewater Treatment Facility in Michigan. Corn is grown as the major cash crop at the Muskegon treatment facility, but experience has shown that corn is not efficient in removing nitrogen from applied wastewater except during a few short weeks during its growing season. Studies were designed to evaluate the improved nitrogen removal for the entire irrigation season when corn is no-till planted in a number of selected forage crops. The effects of competition from the intercropped forages on corn yield were also evaluated along with wastewater spiked with nitrogen during the last two irrigation seasons.

In addition to nitrogen stripping studies, sludge compatibility and metal contaminated sludge studies were evaluated to determine the feasibility of applying sludge to land which is being used in a wastewater treatment system. The major emphasis of the sludge studies was to determine the loss of nitrogen and metals by leaching from sludge applied to a municipal wastewater irrigated land treatment site.

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FOREWORD

The U.S. Environmental Protection Agency was established to coordinate the administration of major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques, and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

The U.S. Environmental Protection Agency's Office of Research and Development conducts this search through a Nationwide network of research facilities. As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs including the development and demonstration of soil and other natural systems for the treatment and management of municipal wastewaters.

The center pivot slow-rate irrigation process for land treatment of municipal wastewaters uses the unsaturated soil profile and the assimulative capacity of growing plants as the treatment medium. At the Muskegon County Wastewater Treatment Facility in Michigan, corn is grown as the major cash crop and the crop revenue is applied toward the capital cost and operation of the system. However, experience has shown that corn is not efficient in removing nitrogen from applied wastewater except during a few short weeks during its growing season. Lack of nitrogen removal by existing practices and elevated nitrogen levels in the groundwater prompted this study by Michigan State University to develop more effective long-term crop management systems to remove nitrogen from wastewater. Farming practices were developed where corn was intercropped with selective forages for increased nitrogen removal for the entire irrigation season without appreciable reduction in corn yield. In addition, sludge compatibility studies were conducted to determine the feasibility of applying municipal sludge to land which is being used as a wastewater treatment system. Results of sludge studies demonstrated that increased yield can be achieved by limited sludge applications without detrimental effects from nitrate leaching.

This report contributes to the knowledge which is essential for the U.S. Environmental Protection Agency to meet requirements of environmental laws and enforce pollution control standards which are reasonable, cost effective, and provide adequate protection for the American public.

Clinton W. Hall

Clinton W. Hall
Director
Robert S. Kerr Environmental Research Laboratory

ABSTRACT

Land renovation of wastewater is an attractive treatment alternative because it can utilize nutrients by a growing crop while removing them from the wastewater. But corn, the common crop utilized in many land treatment systems, takes up a large percentage of its nitrogen (N) during a four week period in mid-summer. This study was conducted to develop more effective crop management systems to remove N from wastewater over a longer period of time during the growing season. Comparisons were made between corn, corn-forage (rye, ryegrass or oats) and forage (ryegrass) to determine the ability of these crop combinations to strip N from wastewater. The use of rye or forage grasses early and late in the growing season was effective in removing N from the wastewater. A management system where corn was no-till planted into an oats, rye or ryegrass cover crop after spraying a strip of the cover crop with paraquat to kill the forage was also developed. Corn alone yielded well, but was not effective in removing N from the wastewater until late July and then for only a short period of time. Corn interplanted with one of the forages was effective in removing N from the wastewater but in many cases the corn yield was reduced because of the competition of the forage with corn for N. Corn in rye yielded about the same as corn alone but corn in ryegrass yielded considerably less than corn alone.

A study to compare different forages showed that corn intercropped with red clover, alfalfa, birdsfoot trefoil and ryegrass gave satisfactory yields. Yields of corn were drastically reduced when tall fescue or orchard grass was the forage of choice. Rye, quackgrass and reed canarygrass were intermediate in their yield efficiency.

A metal-comtaminated sludge was used to study the compatibility of sludge application to land being used in a wastewater treatment system. The sludge used was, in general, high in Cu, Fe, Ni, Cr, and Zn, above average in Cd and Pb and average in Mn.

Yield of corn was increased about 20 hl/ha on the average. There was little advantage in applying greater than 11 T/ha of sludge as far as yield was concerned. Although some yield increase was obtained with addition of 22 T/ha of sludge, economically the returns would favor application of a 11 T/ha rate over a larger acreage. The only heavy metal to be increased significantly in the grain was Zn. Three heavy metals, Zn, Cu and Ni, were shown to leach in the soil and to give increased levels in the groundwater under the highest sludge application rate (3,490, 930 and 770 kg/ha of Zn, Cu and Ni respectively). Low rates of sludge (i.e. less than 54 T/ha) did not appear to be a hazard to either the crop or to groundwater contamination by leaching on these sandy soils.

This report was submitted in fulfillment of Grants No. G-005292 01 and R805270010 by Michigan State University to the U.S. Environmental Protection Agency and covers the period from April 1976 to September 1979.

CONTENTS

- Foreward . . . iii
- Abstract . . . iv
- Figures . . . viii
- Tables . . . x
- List of Symbols and Abbreviations . . . xvii
- Acknowledgement . . . xviii

- 1. Introduction . . . 1
- 2. Conclusions . . . 3
- 3. Recommendations . . . 5
- 4. Experimental Methods . . . 6
  - Field operations . . . 6
    - Site description . . . 6
    - Treatments and plot arrangement . . . 6
      - N-stripping . . . 6
      - Forage crop evaluation . . . 9
      - Metal contaminated sludge . . . 9
    - Crop establishment . . . 10
    - Sampling procedures . . . 10
    - Analytical methods . . . 11
    - Schedule of operations . . . 12
- 5. Results and Discussion . . . 15
  - Nitrogen stripping experiment . . . 16
    - Cropping systems . . . 16
    - Wastewater . . . 17
    - Soil and groundwater . . . 18
      - Chloride . . . 18
      - Ammonium . . . 20
      - Nitrate . . . 21
      - Effect of sludge application on nitrate leaching . . . 31
    - Plant tissue . . . 32
    - Corn yields . . . 32
    - Nutrient removal . . . 36
  - Metal contaminated sludge experiment . . . 38
    - Nutrient and heavy metal loading rates . . . 38
      - Nutrient additions . . . 38
      - Metal additions . . . 40
    - Yield and economic benefit of sludge . . . 41
    - N uptake . . . 42
    - P uptake . . . 45

K uptake 46
Ca and Mg uptake 47
Heavy metal uptake 49
DTPA extractable heavy metals in soils 52
Groundwater analysis 57
Effect of sludge on bases and soil reaction. 59
Soluble salts. 61
Effect of sludge application of soil properties. . . . 61
    Cation exchange capacity. 61
    Pore space and bulk density 61

References 65

Appendix A--Data for N-stripping Experiments. 66

Appendix B--Data for Metal Contaminated Sludge Experiments. 132

FIGURES

Number		Page
1	Plot arrangement for low nitrogen and metal contaminated sludge experiments.	7
2	Plot arrangement for low and high nitrogen N-stripping experiments	8
3	Mean nitrate concentation in 1976 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater . . .	24
4	Mean nitrate concentration in 1977 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater	25
5	Mean nitrate concentration in 1977 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied high N wastewater.	26
6	Mean nitrate concentration in 1977 well water samples from the surface of the water table below various sludge amended corn treatments and total N concentration of the applied high N wastewater.	27
7	Mean nitrate concentration in 1978 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater	28
8	Mean nitrate concentration in 1978 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied high N wastewater.	29
9	Mean nitrate concentration in 1978 well water samples from the surface of the water table below various sludge amended corn treatments and total N concentration of the applied high N wastewater.	30
10	Zinc content of corn tissue and grain grown in 1978 as affected by total Zn applied in sludge	51
11	DTPA extractable Zn in soils as affected by Zn applied in sludge in 1976.	54

Number Page

12 DTPA extractable Cu in soils as affected by Cu applied in sludge in 1976. 55

13 DTPA extractable Ni in soils as affected by Ni applied in sludge in 1976. 56

TABLES

Number		Page
1	Summary of Field Operations	12
2	Amount of Wastewater Applied Each Season	17
3	Summary of the Chemical Composition, Specific Conductivity and pH of the Applied Wastewater	19
4	Chloride Content of Soils--N-Stripping Experiment	20
5	Ammonium Content of Soils--N-Stripping Experiment	21
6	Nitrate Content of Soils--N-Stripping Experiment	22
7	Nitrate Content of Soils as Affected by Sludge Application and High N Wastewater	32
8	Yields of Corn and Silage on N-Stripping Experiment	33
9	Corn Yields on the Supplementary Forage Plots in 1978	34
10	Estimate of N Loss Through Discharge to Tile Drainage During the 1977 Irrigation Season	35
11	Estimate of N Loss Through Discharge to Tile During the 1978 Irrigation Season	36
12	Amount of Nutrients Harvested in Corn Grain and Silage from the Nitrogen Stripping Experiment	37
13	Sludge Analysis and Heavy Metal, Nutrient Loadings (1976-1978)	39
14	Grain Yields from Metal Contaminated Sludge Study	41
15	Dry Matter Yields of Samples from Sludge Plots in 1976	43
16	N Content of Tissue from Sludge Plots in 1976	43
17	Effect of Sludge Application on Relative Uptake of N, P, K, Ca and Mg by Corn	44

Number Page

18 P Content of Tissue from Sludge Plots in 1976 45

19 K Content of Tissue from Sludge Plots in 1976 46

20 Ca Content of Tissue from Sludge Plots in 1976. 47

21 Mg Content of Tissue from Sludge Plots in 1976. 48

22 Cu Content of Tissue from Sludge Plots in 1976. 49

23 Zn Content of Tissue from Sludge Plots in 1976. 50

24 Cd Content of Tissue from Sludge Plots in 1976. 52

25 Comparison of Heavy Metal Content of Groundwater under Highest Sludge Plot and a No Sludge Plot. 58

26 Soil Reaction from Metal-Contaminated Sludge Plots. 60

27 Specific Conductance of Metal-Contaminated Sludge Plots 62

28 Physical Properties of the Sludge Amended Soils (1976). 63

29 Physical Properties of the Sludge Amended Soils (1978). 64

A-1 Weekly Averages of Wastewater Constituents Applied to Low N Plots in 1976 66

A-2 Weekly Averages of Wastewater Constituents Applied to Low N Plots in 1977 67

A-3 Weekly Averages of Wastewater Constituents Applied to High N Plots in 1977 68

A-4 Weekly Averages of Wastewater Constituents Applied to Low N Plots in 1978 69

A-5 Weekly Averages of Wastewater Constituents Applied to High N Plots in 1978 70

A-6 Nitrate, Ammonium and Chloride Content of Soil Samples from Low N Corn in 1976. 71

A-7 Nitrate, Ammonium and Chloride Content of Soil and Well Samples from Low N Corn Ryegrass in 1976. 72

Number **Page**

A-8 Nitrate, Ammonium and Chloride Content of Soil and Well Samples from Low N Ryegrass in 1976 73

A-9 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from Low N Corn in 1977. 74

A-10 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from Low N Corn in Rye in 1977 75

A-11 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from Low N Corn in Ryegrass in 1977. 76

A-12 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from Low N Ryegrass Hay in 1977. 77

A-13 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from High N Corn in 1977 78

A-14 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from High N Corn in Rye in 1977. 79

A-15 Nitrate, Ammonium, Kjeldahl N, and pH of Soil Samples from High N Ryegrass Hay in 1977 80

A-16 Parameters Monitored in Soil Samples from 7 T/Ha Sludge Applied to High N Corn in 1977. 81

A-17 Parameters Monitored in Soil Samples from 22 T/Ha Sludge Applied to High N Corn in 1977. 83

A-18 Parameters Monitored in Soil Samples from Low N Corn in 1978. . 85

A-19 Parameters Monitored in Soil Samples from Low N Corn in Rye in 1978. 86

A-20 Parameters Monitored in Soil Samples from Low N Corn in Ryegrass in 1978. 87

A-21 Parameters Monitored in Soil Samples from Low N Ryegrass Hay in 1978 88

A-22 Parameters Monitored in Soil Samples from High N Corn in 1978 . 89

A-23 Parameters Monitored in Soil Samples from High N Corn in Rye in 1978. 90

Number Page

A-24 Parameters Monitored in Soil Samples from High N Ryegrass Hay in 1978. 91

A-25 Parameters Monitored in Soil Samples from 7 T/Ha Sludge Applied to High N Corn in 1978 92

A-26 Parameters Monitored in Soil Samples from 22 T/Ha Sludge Applied to High N Corn in 1978 94

A-27 Parameters Monitored in Soil Samples from N-Stripping Plots in 1977. 96

A-28 Parameters Monitored in Soil Samples from N-Stripping Plots in 1978. 99

A-29 Parameters Monitored in Well Samples from Low N Corn in 1977 . . 104

A-30 Parameters Monitored in Well Samples from Low N Corn in Rye in 1977. 105

A-31 Parameters Monitored in Well Samples from Low N corn in Ryegrass in 1977 106

A-32 Parameters Monitored in Well Samples from Low N Ryegrass in 1977. 107

A-33 Parameters Monitored in Well Samples from High N Corn in 1977. . 108

A-34 Parameters Monitored in Well Samples from High N Corn in Rye in 1977. 109

A-35 Parameters Monitored in Well Samples from High N Ryegrass in 1977. 110

A-36 Parameters Monitored in Well Samples from 7T/Ha Sludge Applied to High N Corn in 1977 111

A-37 Parameters Monitored in Well Samples from 22T/Ha Sludge Applied to High N Corn in 1977 112

A-38 Parameters Monitored in Well Samples from Low N Corn in 1978 . . 113

A-39 Parameters Monitored in Well Samples from Low N Corn in Rye in 1978. 114

A-40 Parameters Monitored in Well Samples from Low N Corn in Ryegrass in 1978 115

Number Page

A-41 Parameters Monitored in Well Samples from Low N Ryegrass in 1978. 116

A-42 Parameters Monitored in Well Samples from High N Corn in 1978. . 117

A-43 Parameters Monitored in Well Samples from High N Corn in Rye in 1978. 118

A-44 Parameters Monitored in Well Samples from High N Ryegrass in 1978. 119

A-45 Parameters Monitored in Well Samples from 7 T/Ha Sludge Applied to High N Corn in 1978 120

A-46 Parameters Monitored in Well Samples from 22 T/Ha Sludge Applied to High N Corn in 1978 121

A-47 Nutrient Content of Plant Tissue from the Nitrogen Stripping Experiment in 1976 122

A-48 Nutrient Content of Plant Tissue Samples from the Nitrogen Stripping Experiment in 1977 123

A-49 Nutrient Content of Plant Tissue Samples from the Nitrogen Stripping Experiment in 1978 124

A-50 Nutrient Content of Grain Samples from Nitrogen Stripping Experiment in 1976 125

A-51 Nutrient Content of Grain Samples from the Nitrogen Stripping Experiment in 1977 126

A-52 Nutrient Content of Grain Samples from the Nitrogen Stripping Experiment in 1978 127

A-53 Heavy Metal Content of Plant Tissue Samples from the Nitrogen Stripping Experiment in 1977 128

A-54 Heavy Metal Content of Plant Tissue Samples from the Nitrogen Stripping Experiment in 1978 129

A-55 Heavy Metal Content of Grain Samples from the Nitrogen Stripping Experiment in 1977 130

A-56 Heavy Metal Content of Grain Samples from the Nitrogen Stripping Experiment in 1978 131

Number **Page**

B-1 DTPA Extracted Heavy Metals from Soil Samples from Sludge Treatments in 1976 132
B-2 DTPA Extracted Heavy Metals from Soil Samples from Sludge Treatments in 1977 135
B-3 DTPA Extracted Heavy Metals from Soil Samples from Sludge Treatments in 1978 143
B-4 Heavy Metal Content of Soil Samples from Sludge Treatments in 1976. 151
B-5 Heavy Metal Content of Soil Samples from Sludge Treatments in 1977. 153
B-6 Heavy Metal Content of Soil Samples from Sludge Treatments in 1978. 156
B-7 Kjeldahl N, Specific Conductivity, and pH of Soil Samples from Sludge Treatments in 1976. 160
B-8 Kjeldahl N, Specific Conductivity, and pH of Soil Samples from Sludge Treatments in 1977. 162
B-9 Kjeldahl N, Specific Conductivity, and pH of Soil Samples from Sludge Treatments in 1978. 165
B-10 Calcium, Magnesium, Potassium, Total P, and Cation Exchange Capacity of Soil Samples from Sludge Treated Corn Plots in 1976. 168
B-11 Calcium, Magnesium, Potassium, Bray P, Total P, and Cation Exchange Capacity of Soil Samples from Sludge Treated Corn Plots in 1977. 170
B-12 Calcium, Magnesium, Sodium, Potassium, Bray P, Total P, and Cation Exchange of Soil Samples from Sludge Treated Corn Plots in 1978. 174
B-13 Heavy Metal Content of Plant Samples from the Sludge Treatments in 1976. 178
B-14 Nutrient Content of Plant Samples from the Sludge Treatments in 1976. 179
B-15 Heavy Metal Content of Plant Tissue Samples from the Sludge Treatments in 1977 180

Number Page

B-16 Heavy Metal Content of Plant Tissue Samples from the Sludge Treatments in 1978 181

B-17 Heavy Metal Content of Grain Samples from the Sludge Treatments in 1977 182

B-18 Heavy Metal Content of Grain Samples from the Sludge Treatments in 1978 183

B-19 Nutrient Content of Plant Tissue Samples from the Sludge Treatments in 1977 184

B-20 Nutrient Content of Plant Tissue Samples from the Sludge Treatments in 1978 185

B-21 Nutrient Content of Grain Samples from the Sludge Treatments in 1977. 186

B-22 Nutrient Content of Grain Samples from the Sludge Treatments in 1978. 187

LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOLS

C --carbon
Ca --calcium
Cd --cadmium
Cl --chloride
Cr --chromimum
Cu --copper
F --fluoride
Fe --iron
Hg --mercury
K --potassium
Mg --magnesium
Mn --manganese
Na --sodium

SYMBOLS

N --nitrogen
NH_4 --ammonium ion
NH_4-N --nitrogen in the ammonium form
NO_3 --nitrate
NO_3-N --nitrogen in the nitrate form
Ni --nickel
OAc --acetate
Pb --lead
P --phosphorus
PO_4 --phosphate or orthophosphate
PO_4-P --phosphorus in the phosphate form
TKN --total Kjeldahl nitrogen (organic nitrogen and ammonia nitrogen)
TOC --total organic carbon

ABBREVIATIONS

cm --centimeters
cms --cubic meters per second
gm/ha --grams per hectare
ha --hectare
hl/ha --hectoliters/hectare
kg/ha --kilograms per hectare
m --meters
mg/l --miligrams per liter
mm --millimeter
T --metric tons

TYPING GUIDE SHEET

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SECTION 1

INTRODUCTION

Although treatment of wastewater by application to land has been in practice for a number of years and many new locations are being considered, the ideal agronomic management system to renovate wastewater and at the same time recycle nutrients into a crop which is both useable as a resource and economical has not been developed. Many of the initial land application sites have utilized corn as the crop. Certainly corn is a crop which has many advantages--it is well adapted to heavy wastewater application, will recycle nutrients into grain which is a valuable resource and is an economically favorable crop. But corn has one disadvantage--corn accumulates a major part of its nitrogen (N) during a very short period of the growing season. One can calculate from the data of Bar-Yosef and Kafkafi (1972) that under their experimental conditions, irrigated corn accumulated more than 90 percent of its N between the fourth and eighth weeks after planting. And this high accumulation in a short period was not dependent upon the N fertility level. Even though low fertility levels gave rise to lower yields and N accumulation, the percentage of N that accumulated during the fourth to eighth week was still the same.

Grass and forage crops are known to absorb nutrients over a much longer portion of the growing season than corn but they are of less value economically. Therefore it is appropriate to determine if intercropping can be developed to allow both for the renovation of wastewater over longer periods of the year and to produce a valuable grain crop at the same time. Although techniques of intercropping are well developed, in most cases they have been applied to situations where soil fertility is high and water is the factor limiting growth. But under conditions at the Muskegon wastewater treatment site, water is not limiting while nutrients are very limiting even without intercropping. Thus, it is important to develop the best management practices to most effectively remove N from wastewater and produce corn at the same time.

The use of sludge on low fertility soils, particularly those with a low cation exchange capacity, appears very attractive. On the one hand, applying sludge to farmland is a relatively inexpensive method of sludge management and may markedly improve the yield of agronomic crops; but on the other hand, heavy metals and N could be leached from the soil. Heavy metals have been of major concern in sludge applications and many studies have evaluated the uptake of heavy metals by crops following sludge applications. However, relatively few studies have been conducted to determine if leaching of the heavy metals is a problem. The sandy soils at Muskegon with low soil pH values coupled with heavy wastewater application offer the maximum opportunity for movement of heavy metals and N from sludges. Thus, studying the use of a metal contaminated sludge under these conditions was of prime interest in this project.

The objectives of the study were:

1. To develop crop management and wastewater management systems which will optimize the stripping of nutrients from wastewater.

2. To determine the compatibility of land application of metal contaminated sludge to land being used for a wastewater treatment system.

3. To determine the loss of N by leaching from sludge applied to land which is being irrigated with wastewater.

This project was initiated in the spring of 1976 as EPA Project #G-005292 01. It was expanded and continued through the 1978 field season and 1979 laboratory phase as EPA Project #R-805270010.

SECTION 2

CONCLUSIONS

N-STRIPPING STUDY

The N added in the wastewater was rapidly converted to NO_3 leaving very low levels of NH_4 in the soil during two of the three years of study. From the fall of 1977 to early summer of 1978, when exceptionally heavy precipitation combined with the application of wastewater gave poor aeration in the soil, levels of NH_4 increased throughout the soil profile. But the values rarely exceeded 4 parts per million (ppm) N as NH_4.

Corn alone was only effective in removing N during a four week period beginning in late July. At other times the NO_3 levels moving through the soil were near those levels applied in the water.

Ryegrass forage was the best treatment for removing N from the wastewater for the entire season. However, during the four week period begining in late July there was little difference between cropping systems with respect to the quantity of N removed.

Intercropping forage with corn reduced the total N leached considerably when compared to corn grown alone. This system was generally N deficient leaving a delicate balance where the corn yields were reduced by as much as 50 percent if the forage was too vigorous (i.e. ryegrass). But when the forage was adequately controlled with paraquat and not to aggressive (i.e. rye or oats) the intercropped corn yielded about the same as corn alone.

A management system where rye is intercropped with corn by killing a strip of the rye with paraquat and then no-till planting corn in the strip will produce a satisfactory management system to effectively strip N from the water and produce a satisfactory yield of corn. The present varieties of rye used in this study did not shatter in the field to reseed themselves in late summer. A search for varieties which would do this could preclude seeding the rye each year.

A study to compare different forages showed that corn intercropped with red clover, alfalfa, birdsfoot trefoil and ryegrass gave satisfactory yields. Yields were drastically reduced when tall fescue or orchard grass was the forage. Rye, quackgrass and reed canarygrass were intermediate in affecting yield.

Chloride (Cl) moved rapidly through the profile after being applied with the wastewater.

When sludge was applied to an area receiving about 24 ppm N in the wastewater, a rate of 7 metric tons/hectare (T/ha) gave little increase in NO_3 in the soil but a rate of 22 T/ha increased the NO_3 in both the surface and the 15 to 30 cm layer of soil. About 20 hectoliters (hl/ha) yield increase in corn yield was obtained by the application of sludge.

METAL-CONTAMINATED SLUDGE STUDY

Yield of corn was increased significantly by the addition of sludge. But rates of application above 11 T/ha did not show appreciable increase in yield over the 11 T/ha rate.

Economically, the returns would favor application of a 11 T/ha rate over a large acreage rather than heavy applications of sludge to small acreages.

Zinc (Zn) was the only metal to be significantly increased in the corn grain by addition of sludge. Although the level was increased from about 30 to 50 ppm Zn in the grain this level is quite safe in a food grain.

Zinc, Copper (Cu) and nickel (Ni) were found to move in the soil and to give increased levels in the groundwater under the highest sludge application rate (3,490, 930, and 770 kilograms (kg/ha) of Zn, Cu and Ni, respectively). Zinc content of the groundwater was increased from about 0.1 ppm to about 0.8 ppm, Cu from 0.04 to 0.13 and Ni from 0.03 to 0.07 ppm under the heaviest sludge application as compared to no sludge.

Low rates of sludge (i.e. less than 54 T/ha) did not appear to be a hazard to either the crop or to leaching on these sandy soils.

SECTION 3

RECOMMENDATIONS

Effective treatment of wastewater by land application must include careful management of the land and crop resources to obtain maximum nutrient removal through high production and simultaneously produce desireable drainage water. Because of the inability of corn to reduce NO_3 in the soil solution during much of the growing season it can not be recommended as the crop except for systems with very low incoming N levels (i.e. less than 10 ppm N in the water being applied to the land).

Land treatment systems receiving wastewater containing high quantities of N should consider forages or forages intercropped with corn to renovate the wastewater. A management system is suggested where rye is intercropped with corn by killing a strip of the rye with a suitable herbicide at the time that corn is no-till planted. This reduces the competition for nutrients in the corn until it reaches a height sufficient that it will shade the rye and thus reduce the competition. A rye that shatters easily could eliminate the need to reseed the rye each August; however, the varieties that were available on the market resisted shattering.

Application of sludge is compatiable with wastewater treatment systems, but the application rate should be kept low. At application rates less than 54 T/ha movement of heavy metals in the soil profile did not appear to be a problem. Uptake and translocation of heavy metals into the grain were only noted in the case of Zn. The recommendation for a low application of sludge will give the greatest economic returns per T of available sludge and at the same time lessen the chance of leaching of metals from the sludge.

SECTION 4

EXPERIMENTAL METHODS

FIELD OPERATIONS

Site Description

The Muskegon County Wastewater Treatment Facility in Michigan was selected as the location for this project. The soils on this facility are sandy and quickly react to the loading of wastewater and sludge. Also this facility is a large land treatment facility that could benefit from the results of this study.

Leaching of nutrients is most easily studied by groundwater monitoring so a site with natural poorly drained soils was selected. This site (circle #26) had been artificially drained with plastic drain tile placed greater than 1.5 m (5 ft) deep and with a 150 m (500 ft) spacing between the tile.

The soils were a complex of AuGres sand (Entic Haplaquod, sandy, mixed, mesic) and Roscommon sand (Mollic Psammaquent, mixed, mesic) with small areas of Saugatuck sand (Aeric Haplaquod, sandy, mixed, mesic, ortstein) and Croswell sand (Entic Haplorthod, sandy, mixed, mesic).

The field had not been farmed for over 30 years and was covered with scrub coniferous and deciduous trees with bracken and other weeds. The site had been cleared with a bulldozer and disked two years before the initiation of this project. As a consequence the field was rough, weedy, infertile and had woody debris scattered in it. The debris (mostly pieces of wood, roots, etc.) were cleared early in 1976 and the plot areas were disked to prepare for seeding.

Treatments and Plot Arrangement

N-Stripping--

Treatments were designed to compare corn (cash crop), corn-rye (cash crop-forage) and alfalfa (forage crop) in stripping nutrients, particularly N, from wastewater. To allow flexibility during the initial year a randomized block design including four treatments and four replications was used (see Figures 1 and 2). Because of the configuration of the irrigation and drain tile, the blocks were irregular but usually in close proximity. The water table was to be sampled on the N-stripping plots so they were 61 m (200 ft) square to prevent contamination from adjacent plots. Plots were

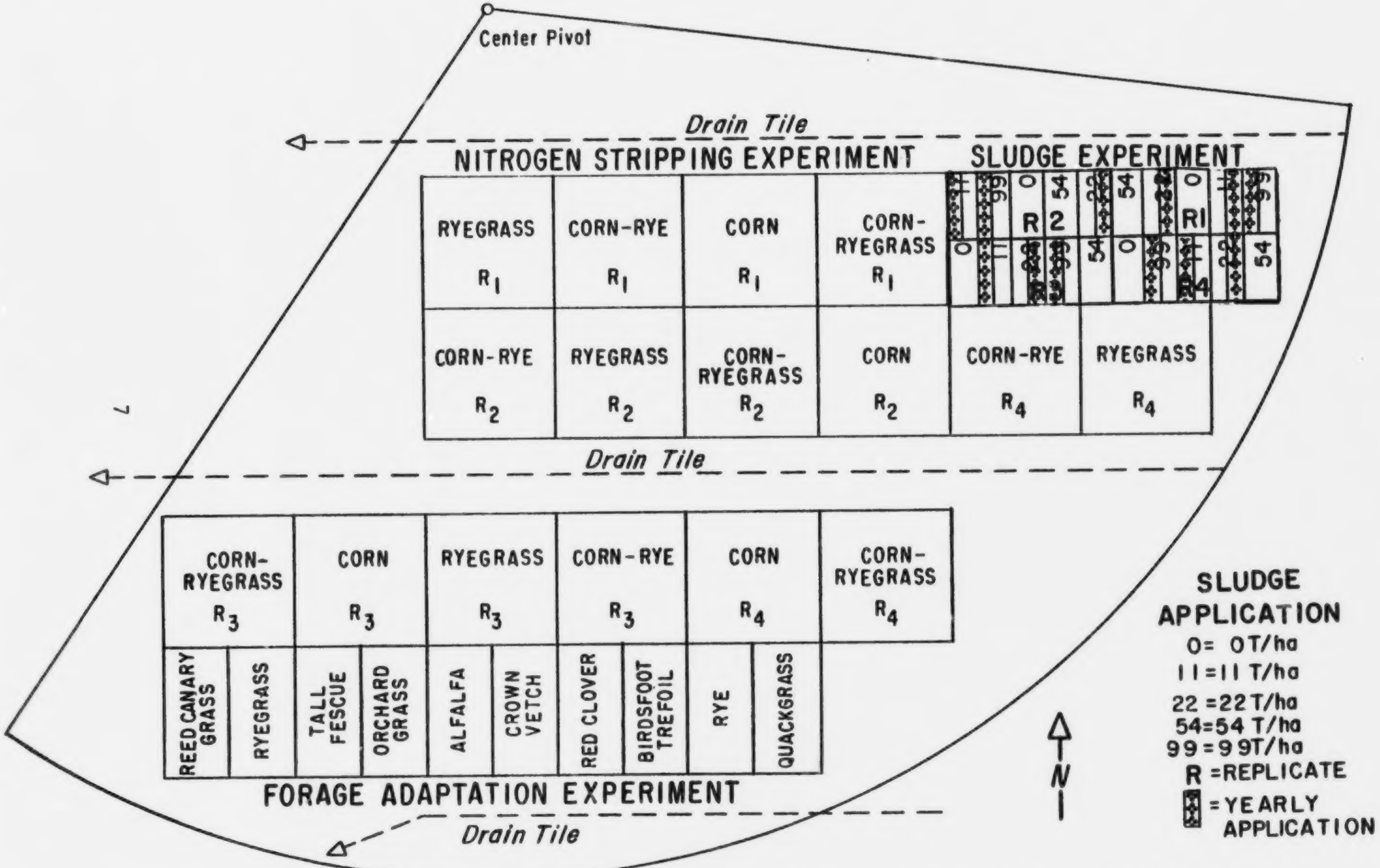
Center Pivot
Drain Tile
NITROGEN STRIPPING EXPERIMENT
SLUDGE EXPERIMENT
RYEGRASS R1
CORN-RYE R1
CORN R1
CORN-RYEGRASS R1
11
99
0
54
22
54
0
R 2
R1
0
11
54
0
99
11
22
54
R4
CORN-RYE R2
RYEGRASS R2
CORN-RYEGRASS R2
CORN R2
CORN-RYE R4
RYEGRASS R4
Drain Tile
CORN-RYEGRASS R3
CORN R3
RYEGRASS R3
CORN-RYE R3
CORN R4
CORN-RYEGRASS R4
REED CANARY GRASS
RYEGRASS
TALL FESCUE
ORCHARD GRASS
ALFALFA
CROWN VETCH
RED CLOVER
BIRDSFOOT TREFOIL
RYE
QUACKGRASS
FORAGE ADAPTATION EXPERIMENT
Drain Tile
N
SLUDGE APPLICATION
0= 0T/ha
11=11 T/ha
22 =22 T/ha
54=54 T/ha
99=99T/ha
R =REPLICATE
▨ =YEARLY APPLICATION

Figure 1. Plot arrangement for low nitrogen and metal contaminated sludge experiments.

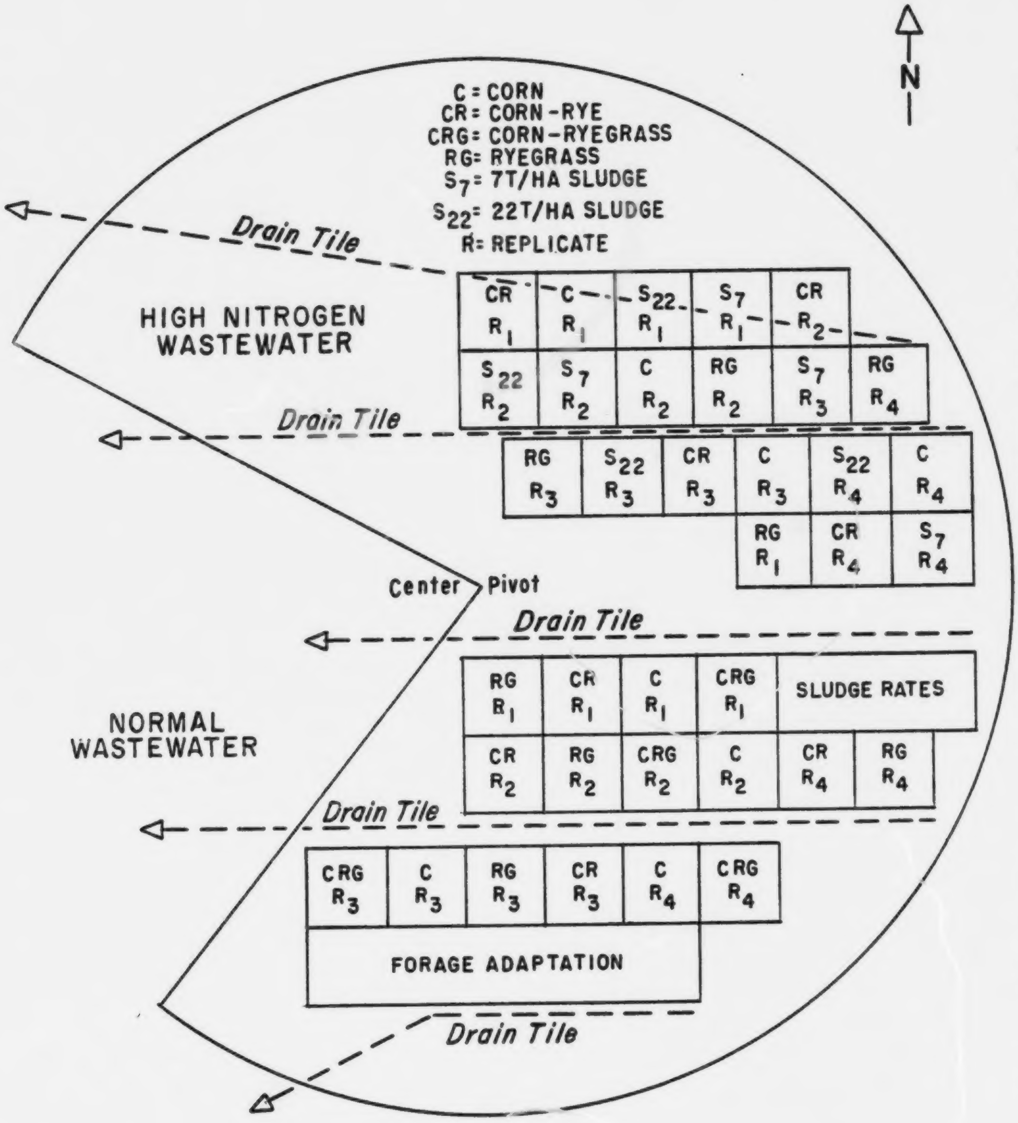
N
C = CORN
CR = CORN-RYE
CRG = CORN-RYEGRASS
RG = RYEGRASS
S7 = 7T/HA SLUDGE
S22 = 22T/HA SLUDGE
R = REPLICATE
Drain Tile
HIGH NITROGEN WASTEWATER
CR R1
C R1
S22 R1
S7 R1
CR R2
S22 R2
S7 R2
C R2
RG R2
S7 R3
RG R4
Drain Tile
RG R3
S22 R3
CR R3
C R3
S22 R4
C R4
RG R1
CR R4
S7 R4
Center Pivot
Drain Tile
RG B1
CR R1
C R1
CRG R1
SLUDGE RATES
NORMAL WASTEWATER
CR R2
RG R2
CRG R2
C R2
CR R4
RG R4
Drain Tile
CRG R3
C R3
RG R3
CR R3
C R4
CRG R4
FORAGE ADAPTATION
Drain Tile

Figure 2. Plot arramgement for low and high nitrogen N-stripping experiments.

also arranged so the common boundary between rows of plots were, in so far as possible, midway between the drainage tile lines. This theoretically minimized the mixing of water draining from one row of plots with the other.

In 1977 a second experiment was established on the north half of the irrigation circle similar to the first but using two sludge treatments (7 and 22 T/ha) with corn in addition to the three primary cropping treatments. This experiment also received high N irrigation water while the initial experiment received normal wastewater. Thus, a randomized block design was used with five treatments and four replications.

The expansion of the project to include a wastewater with a higher N content which would be representative of more wastewaters (since Muskegon wastewater is normally low in N and other nutrients) and sludge additions was started on the north portion of the circle (Figure 2). Twenty-five ppm N as a liquid fertilizer (28 percent N) was injected into the wastewater whenever the irrigation rig was in this part of the field.

Forage Crop Evaluation--

An experiment (not replicated) was established in the spring of 1976 at the south end of the circle to determine which forages were best adapted to the wastewater farm environment. These forage adaptation plots were 30.5 m (100 ft) x 61 m (200 ft) and were unreplicated. They included the following crops: reed canarygrass - *Phalaris arundinacea*, perennial ryegrass - *Lolium perenne*, tall fescue - *Festuca arundinacea*, orchard grass - *Dactylis glomerata*, alfalfa - *Medicago sativa*, crown vetch - *Coronilla varia*, red clover - *Trifolium pratense*, birdsfoot trefoil - *Lotus comiculatus*, rye - *Secale cereale*, and quackgrass - *Agropyron repens*.

Metal Contaminated Sludge--

An experiment was established to study the influence of metal loading rates from a metal contaminated sludge upon crop yield and the movement of heavy metals under irrigation. A randomized block design with five treatments (0, 11, 22, 54, and 99 T sludge/ha) and four replications was used (see Figure 1). The experiment was modified by splitting the 11, 22 and 99 T/ha treatments in 1977 and adding yearly sludge applications to one half of each plot. The sludge plots were established by spreading weighed quantities of a heavy metal contaminated sludge (source of sludge was the municipal wastewater treatment facility in Grand Rapids, Michigan) which was delivered to the site by truck. Each load of sludge applied was sampled and analyzed. Although some differences existed in the nutrient and metal content of the individual loads, these differences were usually less than ten percent. The low rates of application were added by using a manure spreader, and the high rates (54 and 99 T/ha) were spread by means of a tractor mounted front-end loader. All treatments were thoroughly disked into the surface soil to give uniform spreading of the sludge. Based on the average percent solids and elemental concentrations, the amount of sludge, nutrients and metals applied each year has been calculated and is given in Table 13.

Crop Establishment

The original objective for the N stripping field experiment was "to compare corn (cash crop), corn-rye (cash crop-forage), and alfalfa (forage crop) in stripping nutrients, particularly N, from wastewater." Corn was planted in 76 cm (30 in) rows with weeds controlled by atrazine for the corn treatments (in the N-stripping experiments and for the metal contaminated sludge plots). Corn variety JX122A was planted in 1976, Funks SX1692 in 1977, and Pioneer 3965, Trojan and Golden Harvest in 1978. Because of the late start in the spring of 1976, substitutions were made to obtain comparative data during the first year. A mixture of Tetralite ryegrass and tall fescue was seeded in 1976 as a substitute for alfalfa as the forage crop. This made it possible to compare a vigorously growing but late planted forage with corn in the first year. The corn-rye treatment was carried through as planned but because there was no overwintered rye in which to plant corn, an extra treatment, forage-corn, was established as quickly as possible. This treatment consisted of a ryegrass and oat mixture which would quicky establish itself and simulate an overwintering forage. The corn was then no-till planted in 76 cm (30 in) rows in the three week old forage with a 23 cm (9 in) wide paraquat treated strip over the row.

Sampling Procedures

The wastewater being applied to the fields was sampled both at the spray nozzles during the application of wastewater and by collection vessels placed within the treatment areas. Although the collection vessels gave verification of uniform application rates, the samples tended to become contaminated with dust and insects. Therefore, once comparisons indicated that the better samples were obtained from the spray nozzels, these data were used.

The movement of nutrients in the soil on the N stripping experiment was followed by weekly soil sampling from the 0-15, 15-30, 30-45 and 46-61 cm layers in 1976. The deepest samples agreed very well with the well samples in 1976 so in 1977 and 1978 only the 0-15 and 15-30 cm layers were sampled weekly and deep samples were taken at the beginning and end of the season. Twenty cores were taken with a 5 cm stainless steel bucket auger, mixed thoroughly in a pail and a subsample for analysis was obtained with a stainless steel sample splitter. The subsample was placed in a plastic bag and refrigerated until analyzed.

The sludge plot soils were sampled monthly using the same method but at 0-15 cm and 15-30 cm depths. The last soil sampling was to a 92 cm depth. Following harvest, 10 soil cores, 7.5 cm in diameter and 7.5 cm deep, were taken from each sludge plot in 1976 and 1978 to evaluate the water retention capacities of the soil as affected by the sludge application.

The groundwater below each plot in the N-stripping experiment was monitored for nutrient leaching. Four slotted 4 cm diameter plastic well points were placed within each plot so that the point reached into the water table. The well water sample was pumped from the upper 2.5 cm of the water table after the well had been flushed by withdrawing and discarding approximately one liter of water. Samples were stored in plastic bottles under refrigeration until analyzed.

Plant tissue samples were taken at four growth stages of corn. The first was taken when most of the corn was "knee high" (50 cm), the second at tasseling, the third at the dent stage of the kernals and finally at harvest. The corn samples were from ten randomly selected plants except for the sludge plots where the second corn sampling (tasseling) consisted of 20 ear leaves per plot. The final sampling of the grain was made at harvest. Forage samples were taken from five 0.562 m^2 areas in each plot. All tissue samples were weighed, dried, reweighed and ground for analysis.

Final corn yields were determined by hand harvesting several 15.2 m rows in each plot, drying to less than 15 percent moisture, reweighing and calculating yields on the basis of 15 percent moisture.

Analytical Methods

Wastewater and well water analyses were analyzed by the following methods: Total Kjeldahl N was determined by a micro-Kjeldahl apparatus and steam distillation to obtain free NH_4-N and organic N (EPA Methods for Chemical Analysis of Water and Waste, 1974); NO_3-N was determined by use of a specific ion electrode if the concentration was greater than 10 ppm N and by an automated Cd reduction method utilizing a Technicon Auto-Analyzer if the content was less than 10 ppm N; NH_4-N content was determined by steam distillation after the sample was made alkaline with sodium hydroxide (NaOH) (EPA, 1974); Cl content was determined with a specific ion electrode; orthophosphate P was determined by the ascorbic acid method of Murphy and Riley (1962) as adapted to Technicon Auto-Analyzer; total P was determined by the same method after digestion by persulfate in 1976 or hydrochloric acid (HCl) in 1977 and 1978 as described by EPA (1974); K, Na, Ca and Mg were determined on HCl digests (EPA, 1974) using a flame photometer; total Cu, Fe, Mn, Zn, Cr, Cd, Ni and Pb were determined on HCl digests using an atomic absorption photometer, also some samples were analyzed by Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma in 1978 using the plasma emission spectrophotometer for comparison purposes; total organic carbon (TOC) was analyzed using a Dohrmann Envirotech organic carbon analyzer; conductivity was determined with a Sohr-bridge; and pH with the glass electrode.

The analytical determinations for soils were the same as for water samples after the ions had been extracted. The extractions were as follows: nitrate N was extracted by saturated calcium sulfate ($CaSO_4$); ammonium N was extracted by 2 N potassium chloride (KCl), available P was extracted by Bray P_1 (0.025 N HCl + 0.03 N NH_4F with a soil to solution ratio of 1:10), and K was extracted with 1 N NH_4OAc at pH 7.0. Total Kjeldahl N was determined by micro-Kjeldahl procedures (Black, 1965). Soil pH determinations were made on 1:1 soil:water suspensions. Exchangeable bases (K, Ca, Mg, Na) were extracted by 1 N NH_4OAc at pH 7.0 and cation exchange capacity was determined by NH_4-N saturation of the soil exchange sites and then analyzing for NH_4-N by steam distillation. Chelate extractable heavy metals were determined by extraction of the soils with DTPA according to the method of Lindsay and Norvell (1969). The extracted heavy metals were determined by atomic absorption methods except for the Hg which was analyzed by use of a Hg analyzer. Total Cu, Fe, Mn, Zn, Cd, Ni, Cr, Pb, and Hg were determined on soil samples that were digested with hydrogen fluoride (HF), nitric acid (HNO_3) and perchloric acid ($HClO_4$) according to the method of Pratt (1965) and analyzed by the same methods outlined above.

Plant tissue or sewage sludge was dried, ground and a 1 gram subsample was digested with HNO_3-$HClO_4$. Individual nutrient and metal analyses were made by the standard methods previously described.

Soil cores collected for measuring water retention and bulk density were saturated with water and then equilibrated on 10, 20, 30, 40 and 60 cm tension tables until equilibrium was established. The water loss between each increasing tension (i.e., saturation to 60 cm) was determined by weight. High tension (100, 330, and 1000 cm) equilibrations were determined by using the pressure plate method. Cores were subsequently oven-dried to determine soil bulk density.

Schedule of Operations

A tabulation of the time of the major field operations is given in Table 1. All operations were performed as timely as possible except for a one month delay in starting the project in 1976.

TABLE 1. SUMMARY OF FIELD OPERATIONS

Date		Field Operation
1976		
April	23 - 30	Disked and cleared field.
	29	Seeded oats and ryegrass on forage and forage-corn plots.
May	3 - 13	Applied sludge.
	7	Limed alfalfa and crown vetch plots.
	12 & 13	Initial soil sampling.
	20 & 21	Corn planted on N-stripping plots.
	25 - 27	Planted supplemental forage plots.
	26	Planted sludge plots.
	28	First wastewater irrigation.

(Continued)

TABLE 1 (Continued)

Date	Field Operation
June 3 & 4	Set wells in N-stripping plots.
7 - 11	Second soil sampling. This began the weekly soil sampling.
10	First well sampling. This began the weekly well sampling.
30	Corn cultivated.
July 2	First plant tissue sampling.
August 4	Second plant tissue sampling.
4 - 6	Planted rye.
Sept. 16	Finished summer irrigation season. Total of 835 mm wastewater applied this season.
20	Killing frost.
23	Plant tissue sampled.
October 19 - 26	Corn harvested and last plant samples taken.
Nov. 22	Final soil and well sampling completed.
1977	
March 9 - 10	First well sampling.
23 - 30	First soil sampling.
29	Planted oats on high N corn-rye plots.
30	Planted ryegrass on high N forage plots.
April 13 - 29	Applied sludge.
May 4 - 9	Planted corn.
11 - 13	Second soil sampling. This began the weekly soil sampling of N-stripping plots.
16	Started irrigation.
17 - 18	Second well sampling. This began the weekly well sampling of N-stripping plots.
27	Soils on sludge compatability studies sampled. This began the monthly soil sampling on these plots.
June 15	Began injection of 25 ppm N on high N plots.
July 6	First plant tissue sampling.
21 & 22	Second plant tissue sampling.

(Continued)

TABLE 1 (Continued)

Date		Field Operation
August	19 & 20	Rye broadcast on corn-rye plots. Finished summer irrigation. Total of 927 mm wastewater applied this season.
Sept.	20 & 21	Corn yield measurements made on N stripping plots.
	28 & 29	Crop yield measurements made on sludge compatability plots.
October	13 & 14	Took soil cores on sludge compatability plots.
	18 - 31	Harvested corn grain on all plots.
October	27 - Nov. 9	Wastewater irrigation as weather permitted. Total of 114 mm wastewater applied after harvest.
Nov.	1 - 30	Disked all corn plots, chopped corn on forage-corn and corn-rye plots.
	14 - 16	Final sludge--soil sampling taken to 920 mm depth.
	21 - 23	Final soil sampling of N-stripping plots taken to 920 mm depth.
	28 & 29	Final well samples taken.
1978		
March	27 - 29	First well sampling (during snow melt).
April	13	First evidence of regrowth of rye and perennials.
	10 - 20	First soil sampling to 457 mm depth.
May	4 - 10	Planted corn on N-stripping plots.
	4	Spread sludge on sludge compatability plots.
	11	Disked and planted corn on sludge plots.
	22	Started wastewater irrigation.
	25	Began N injection to the high N treatment.
June	8	Took first forage samples prior to harvest.
	23 & 26	Sludge soils sampled.
July	6	First plant tissue sampling.
	17 & 18	Sludge soils sampled.
	17 - 22	Rye planted on corn-rye plots.
	25 - 27	Second plant tissue sampling.
August	21 & 22	Sludge soils sampled.

(Continued)

TABLE 1 (Continued)

Date		Field Operation
Sept.	11	Finished summer irrigation season. Total of 673 mm wastewater applied.
	20	Sludge soils sampled.
	22 - 28	Corn yield samples taken from N-stripping plots.
	28	Corn yield samples taken from supplemental forage plots.
October	13 & 14	Corn yield samples taken from sludge plots.
	18	Began fall irrigation on south side, low N, sludge & supplemental forage only.
Nov.	6 & 7	Disked corn plots.
	7 - 15	Sampled deep soils on high N-stripping plots.
	15	Finished fall irrigation. Total of 343 mm of wastewater applied to low N plots.
	15 - 17	Final soil sampling on sludge plots to 920 mm depth.
	18 - 24	Soil core samples taken from sludge plots.
	14 - 27	Sampled soils on low N-stripping plots to 920 mm depth.

SECTION 5

RESULTS AND DISCUSSION

NITROGEN STRIPPING EXPERIMENT

Cropping Systems

The crops and cropping systems that were compared in the N stripping were corn, forage, corn-forage and corn-rye. The corn performed well as an economic crop but as later data for soil and groundwater analyses will verify, it renovated wastewater only for the short period of time when it was growing vigorously. The forage which had been planted as a mixture of Tetralite ryegrass and tall fescue in 1976 quickly became a stand of ryegrass due to the aggressiveness of the ryegrass. This was to demonstrate the best renovation that could be performed by crops as this ryegrass is a very rapid growing, high yielding grass with a long growing season. Corn-forage and corn-rye treatments were used to study cropping systems in which the nutrients were harvested in a corn crop but intercropping was used to improve the nutrient uptake over a longer period of time. The intercrop of rye was not seeded to rye until August, 1976 and the forage was actually oats planted with ryegrass in 1976 and a ryegrass-weed mixture developed in the succeeding years. The corn was no-till planted into the rye or ryegrass while killing the vegetation in the row with Paraquat using shields to protect a 10-15 cm strip between the rows. This strip of rye or ryegrass was left to continue to absorb nutrients as the corn germinated and began to grow.

It was postulated that the strip of ryegrass would eventually develop a complete cover by the time the corn was harvested and that the rye would mature and reseed itself in August for fall germination and growth. The ryegrass did maintain itself fairly well but became progressively weedier. If the field had been weed free at the start the system might have been more successful.

Rye is a winter grain which is planted in the late summer. It germinates and grows in the fall and is dormant or slow growing in the winter. In the spring the rye grows rapidly and matures in early summer. Its period of maturing and reseeding is the same period in which corn is growing most rapidly and absorbing nutrients at the greatest rate. In this way corn and rye compliment each other almost perfectly. The problem with using the present commercial varieties of rye is that they are selected for their non-shattering ability so the grain can be harvested. Therefore, even though there was plenty of rye produced for reseeding the seed dropped much too late to form a good cover by corn harvest. Rye was broadcast seeded each August to simulate a shattering rye. In actual practice if a shattering rye cannot be found the rye could be broadcast seeded by airplane.

Wastewater

The amount of wastewater applied with each passing of the irrigation bar was studied very intensively during the 1976 irrigation season. Cups for measuring the effluent were placed at each well site and the amount of wastewater was measured after each irrigation. There was considerable variation in the individual measurements but a thorough analysis of the data did not show a consistent variation along the length of the irrigation system. The amount of water applied for the whole season was 12.4 mm (0.5 in) for each pass of the irrigation rig.

The total wastewater applied during each season is tabulated in Table 2. These values are much lower than the 1780 mm (70 in) per year for which the system was designed. The original poorly drained soils with a less than adequate tile drain system are reasons for the application of less than the designed amounts on this circle. There was no fall application in 1976 because of the late planting and slow drying of the corn and the early subfreezing temperatures that precluded late fall application after harvest. The extremely wet conditions on the high N side in 1978 prevented fall irrigation on the north side.

TABLE 2. AMOUNT OF WASTEWATER APPLIED EACH SEASON

Year	Season		Amount mm
1976	Summer		835
1977	Summer		927
	Fall		114
		Total	1041
1978	Summer		673
	Fall (Low N only)		343
		Total Low N	1016

The chemical characteristics of the wastewater are tabulated in Tables A-1 to A-5 in the Appendix. There is considerable variation in the composition of the wastewater from day to day depending on how it is being blended. The most notable variation is during the period of the large N demand by corn in late June, July and early August when N is injected as part of the crop management by the County. The average nutrient contents, specific conductivities and pH values of the wastewater are shown in Table 3. The Muskegon wastewater is low in P and N due to the large proportion of industrial waters in it. The N injection for the high N boosts the average total N from 16 ppm to 24.4 ppm which is less than was wanted but there appeared to be a loss by volatilization in the spraying.

Soil and Groundwater

Data for the soil analyses from this experiment are given in the Appendix Tables A-6 to A-8 for 1976, Tables A-9 to A-17 for 1977 and Tables A-18 to A-26 for 1978. Each value reported for soil is an average of four replications and is reported as ppm in oven dry soil. Generally the sandy soil from these plots contains 20 percent moisture at the point of appreciable water movement; therefore, if the ppm in the soil are multiplied by five an approximation of the concentration in the soil solution is obtained.

Chloride--

The Cl data serves to trace the movement of the applied effluent in the soils. The background levels in 1976 (Table 4) and (Tables A-6 to A-8) were about 4 ppm Cl in the soil. The wells were low in the first week that they were sampled except for those under ryegrass. Under this plot the next week (week 21) the value was 30 ppm Cl indicating possible contamination in installation of the well. This increased greatly due to the high Cl content of the effluent. The wastewater was at the 15 cm depth by the 25th week and at 60 cm by the 27th week. After the initial contact with the percolating wastewater, Cl in the soil increased and fluctuated but never came back to the original background level in spite of the flushing of rainwater and snowmelt during the non-irrigated season. But the Cl level did decline in soil and particularly in the groundwater during the periods when wastewater was not applied. Thus, in 1976 the final value in the wells was from 50 to 70 ppm as compared to values well over 200 during the period of time when maximum wastewater was being applied. This effect is particularly noticeable in 1978 when higher than usual precipitation caused considerable dilution. The average Cl content of wells in 1978 was just 59% of that in 1977. In 1977 (Tables A-16 and A-17) the establishment of the sludge treatments on the high N side of the experiment produced Cl levels in excess of 100 ppm in the surface soil on these plots. Within two weeks these levels had dropped to less than 100 ppm Cl and by the 28th week were as low or lower than treatments receiving no sludge.

TABLE 3. SUMMARY OF THE CHEMICAL COMPOSITION, SPECIFIC CONDUCTIVITY AND pH OF THE APPLIED WASTEWATER

Year and N/level	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	ppm										µ/mhos	
1976 Low N	5.1	3.13	9.62	14.48	240	2.20	2.30	10.9	65.5	14.4	1070	8.11
Std. Dev.	5.4	2.04	4.96	6.05	54	0.44	0.54	1.6	10.4	1.9	150	0.26
1977 Low N	4.28	6.00	12.58	16.86	280	2.24	2.31	10.9	70.2	19.5	980	7.73
Std. Dev.	6.11	4.09	9.48	15.20	77	0.23	0.41	2.1	8.9	7.9	140	0.26
1977 High N	6.01	8.54	18.54	24.55	271	2.22	2.46	10.7	69.1	20.2	980	7.76
Std. Dev.	6.72	5.77	13.96	20.05	64	0.21	0.75	1.1	9.2	8.8	130	0.27
1978 Low N	3.85	5.84	12.68	16.53	181	1.58	1.68	15.0	86.5	14.7	1080	7.75
Std. Dev.	2.72	6.37	10.83	12.54	19	0.30	0.53	5.0	20.0	1.3	130	0.29
1978 High N	5.80	10.25	18.45	24.25	182	1.70	1.92	16.6	86.8	14.4	1110	7.79
Std. Dev.	2.67	7.79	16.24	17.24	19	0.22	0.36	4.5	23.4	1.5	130	0.19
Low N Avg.	4.41	4.99	11.63	15.96	233.67	2.01	2.10	12.27	74.07	16.2	1043	7.86
High N Avg.	5.90	9.40	18.50	24.40	226.5	1.96	2.19	13.65	77.95	17.3	1045	7.78

TABLE 4. CHLORIDE CONTENT OF SOILS--N-STRIPPING EXPERIMENT

Year	Sample	Treatment					
		Corn		Corn-Rye		Ryegrass	
		Low N	High N	Low N	High N	Low N	High N
		ppm Cl					
1976	Week 20* 0-15 cm	4.1		4.0		3.7	
1976	Week 20 61-91 cm	2.8		1.9		1.9	
1976	Week 24 wells	18.6		38.5		71	
1976	Average 0-15 cm	34.0		35.7		40.6	
1976	Average 61-91 cm	12.9		14.1		11.6	
1976	Average wells	132		141		145	
1977	Average wells	239	199	246	210	263	206
1977	Week 46 wells	186	157	190	170	180	182
1978	Average wells	130	135	128	143	135	133

*Denotes week of the calendar year.

Ammonium--

The NH_4-N levels were initially low and stayed low (Table 5). In 1976 the values were mostly in the 1 to 2 ppm range for the surface soil and lower in the deeper horizons indicating that the NH_4 was rapidly being nitrified to NO_3 in these well aerated, sandy soils. Similar results were found in 1977 except that the last sample in the fall showed an increase in NH_4 in the 0 - 15 and 15 - 30 cm layers which was probably the effect of low temperature inhibiting the nitrifying organisms. These higher values were still present early in 1978. The NH_4 concentrations in 1978 remained higher and did not decline as much as in the previous season because of the failure of the drainage system on this circle. Very late in the 1978 season a combination of a dry fall which allowed the water table to fall and the relatively warm weather which allowed nitrification resulted in decreased NH_4 concentrations again. There were no significant differences between the NH_4 distributions in soil due to the cropping systems. Complete data is given in Tables A-6 through A-26. The well data reflect values less than 1 ppm N as NH_4 during the three year study. The trend was for decreasing concentrations of NH_4 in the groundwater during the experiment. But with all values less than 1 ppm N, changes were not significant.

TABLE 5. AMMONIUM CONTENT OF SOILS--N-STRIPPING EXPERIMENT

Year	Sample	Treatment					
		Corn		Corn-Rye		Ryegrass	
		Low N	High N	Low N	High N	Low N	High N
		ppm N as NH_4					
1976	Week 20* 0-15 cm	1.8		1.4		1.6	
1976	Week 20 15-30 cm	1.1		0.8		1.1	
1976	Week 24 wells	0.8		0.7		1.1	
1976	Average 0-15 cm	1.7		1.6		1.5	
1976	Average 15-30 cm	1.3		1.3		1.3	
1976	Average wells	0.4		0.4		0.6	
1977	Average 0-15 cm	1.5	1.5	1.7	1.5	2.3	2.4
1977	Average 15-30 cm	1.2	1.3	1.3	1.4	1.5	1.5
1977	Average wells	0.2	0.4	0.2	0.3	0.2	0.7
1977	Week 47 0-15 cm	3.1	4.4	4.0	5.2	3.8	6.9
1977	Week 47 15-30 cm	2.3	3.7	3.1	3.3	4.2	3.5
1977	Week 46 wells	N.D.	0.1	0.1	0.3	N.D.	0.3
1978	Average 0-15 cm	4.1	4.1	5.6	6.1	6.9	5.4
1978	Average 15-30 cm	3.2	3.6	3.4	4.6	3.5	2.1
1978	Average wells	0.1	0.3	0.1	0.5	0.1	0.7
1978	Week 48 0-15 cm	1.5	2.0	2.6	1.4	3.2	4.4
1978	Week 48 15-30 cm	1.6	3.3	1.5	2.0	4.2	3.9
1978	Week 47 wells	N.D.	0.1	0.1	0.2	0.2	0.1

*Denotes week of the calendar year.

Nitrate--

The NO_3 in the soils started out rather low (1.9 - 2.5 ppm) in 1976 (Table 6). There was an initial increase in NO_3 before the first effluent was applied due to the initial cultivation and decomposition of the original plant material (Tables A-6 through A-8). The NO_3 levels in soil were lower in the lower layers of soil. This is attributed to plant uptake of NO_3 which caused the reduction of NO_3 with depth in the soil. The corn-ryegrass treatment in 1976 was planted as an oats-ryegrass mixture. The oats quickly became established and reduced the NO_3 in the soil to the lowest concentration of the three treatments. The soil under the ryegrass treatment was intermediate in NO_3 because the ryegrass developed more slowly. The treatment of corn alone did not reduce soil NO_3 until after July when the corn had developed a full canopy and was in its stage of rapid growth. Therefore, it was the poorest treatment for removing NO_3 from the soil on the average but it was comparable to other treatments from the 34th to the 38th week. All treatments became less effective in reducing soil NO_3 after August. There was an increase of NO_3 in the soil on all treatments in the fall months without wastewater additions because of residue decomposition and slowed growth of the ryegrass.

The low N plots of 1976 were continued into 1977 (Table A-9 to A-11) and the ryegrass which was now well established always had the lowest NO_3 in the surface soil. In May and June the corn-ryegrass and corn-rye soils had less NO_3 than the corn alone. However in August and September the vigorously growing corn in the corn alone treatment had the same or slightly lower surface soil NO_3 content than the intercropped corn. Soil from the 15-30 cm depth under ryegrass and corn-ryegrass usually had one-half the NO_3 as compared to NO_3 levels under corn alone early in the season. The corn-rye was intermediate in NO_3 removal.

TABLE 6. NITRATE CONTENT OF SOILS--N-STRIPPING EXPERIMENT

		Treatment					
Year	Sample	Corn		Corn-Rye		Ryegrass	
		Low N	High N	Low N	High N	Low N	High N
		ppm N as NO_3					
1976	Week 20[*] 0-15 cm	1.9		2.5		2.2	
1976	Week 20 15-30 cm	1.7		1.8		1.6	
1976	Average 0-15 cm	3.5		2.2		3.1	
1976	Average 15-30 cm	2.1		1.6		1.8	
1977	Average 0-15 cm	4.3	7.1	4.7	7.0	2.9	5.6
1977	Average 15-30 cm	1.8	3.4	1.4	3.1	0.9	2.4
1977	Week 47 0-15 cm	2.0	2.8	2.1	4.1	0.9	2.5
1977	Week 47 15-30 cm	0.8	1.0	1.1	1.8	0.3	1.0
1978	Average 0-15 cm	3.7	4.4	4.0	4.0	2.7	3.1
1978	Average 15-30 cm	1.7	2.1	1.6	1.9	1.2	1.4
1978	Week 48 0-15 cm	3.8	10.4	3.7	11.4	3.5	7.2
1978	Week 48 15-30 cm	1.5	3.5	1.0	4.4	1.4	2.1

[*] Denotes week of the calendar year.

The high N plots were established in 1977. As in previous experiments, oats were used to simulate overwintering rye. All plots had an initial content of about 15 ppm N as NO_3 in the surface soil. The ryegrass grew quickly and reduced NO_3 in the surface soil to about 5 ppm N in four weeks. The corn-oats system was intermediate in reducing NO_3 content of the surface soil. At the 15-30 cm depth the intercropped corn reduced the NO_3 content of soil beginning in June to below that of corn alone. The soil under ryegrass plots always had the lowest NO_3 content. The corn-oats system was similar to corn alone in July, but in August as the oats matured the corn in both treatments did equally well in reducing NO_3 in the profile.

The most significant changes as far as this N-stripping project is concerned are the changes in NO_3-N concentration in the leached water. These are graphed in Figures 3 to 9.

In 1976 (Figure 3) the corn-rye treatment which had oats in the first year kept the NO_3-N in the well water lowest early in the season reflecting the uptake of NO_3 by the quick growing oats. These low concentrations were continued by the NO_3 stripping of the ryegrass and corn. The ryegrass plot initially lost NO_3-N by leaching, but as the grass became established it was very efficient at removing NO_3-N. The corn alone only stripped NO_3-N for a month which showed up in low NO_3-N well samples in August. The average NO_3-N concentration in the well water for the first season was 3.7 ppm for the corn-ryegrass with oats, 6.2 ppm for the ryegrass alone and 8.0 ppm for the corn alone.

At the end of the irrigation season in 1976 there was a large increase in the NO_3-N in the effluent. This was reflected in the well water within a week or two demonstrating the sensitivity of the well water sampling procedures.

The similarity of the well water analyses and the deep soil analyses once the correction for water content is made caused the elimination of the weekly deeper soil samplings in 1977 and 1978. These soil samples were tedious and difficult to take because of an ortstein layer in some areas. The well samples did seem to give a reasonable estimate of the quality of water that was leaching through the plots and into the groundwater and subsequently drained by the tile drainage system.

In 1977 the low N experiment (Figure 4) showed the benefits of the intercropping systems at reducing NO_3-N in the leaching after the initial starting year of 1976 when all the treatments were not complete. The corn alone was poorest at reducing NO_3. The NO_3-N in the well water was rarely below 5 ppm and during periods when extra N was being added to increase corn production on the farm the concentrations rose above 15 ppm. The corn-rye system was always better and had on an average about one half as much NO_3 in well water and never allowed a concentration over 10 ppm. The ryegrass had the lowest NO_3 in well water averaging 2.1 ppm and with only one value above 5 ppm. The corn-ryegrass intercrop system was quite similar to ryegrass alone but this was because the ryegrass was not sufficiently controlled to

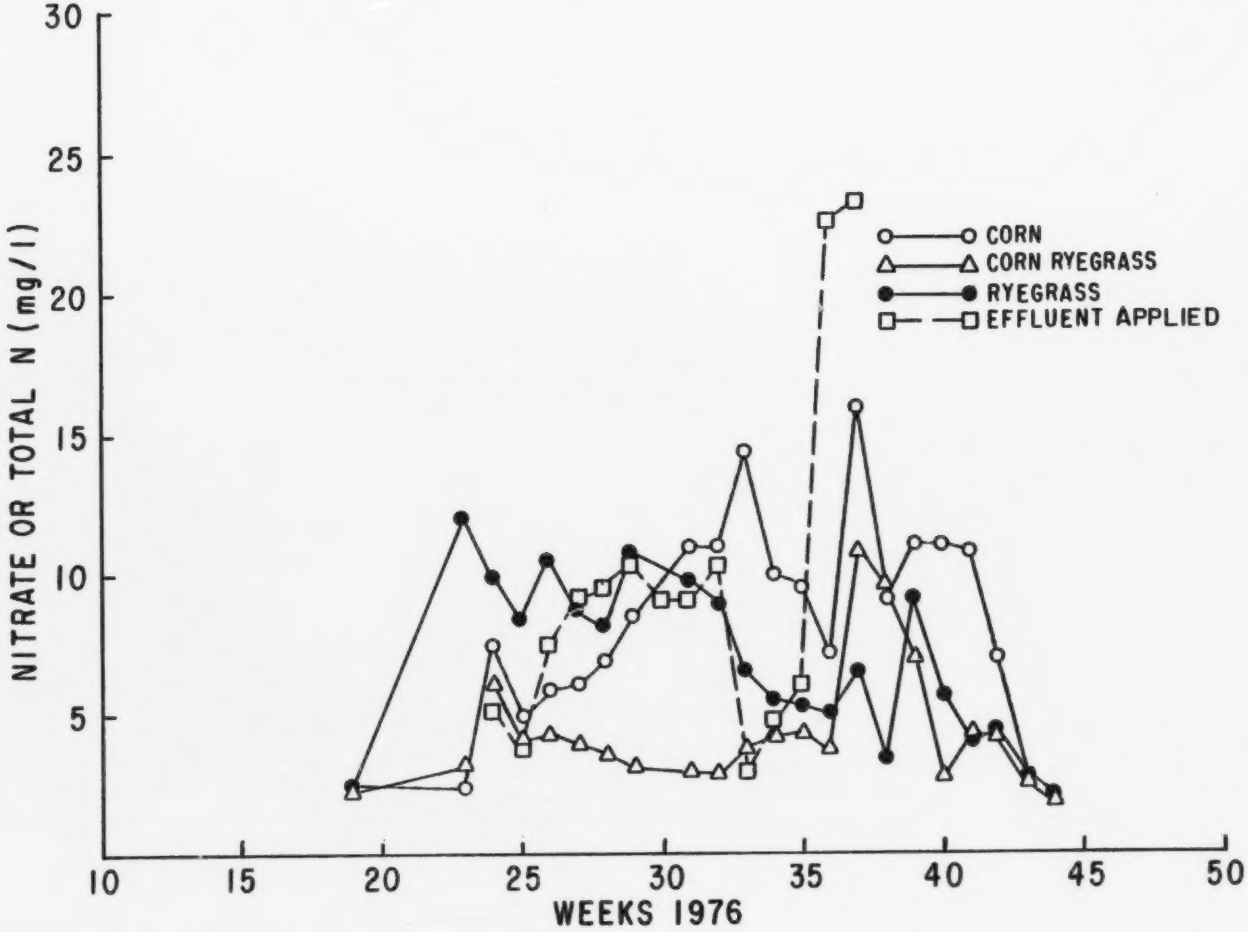

Figure 3. Mean nitrate concentration in 1976 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater.

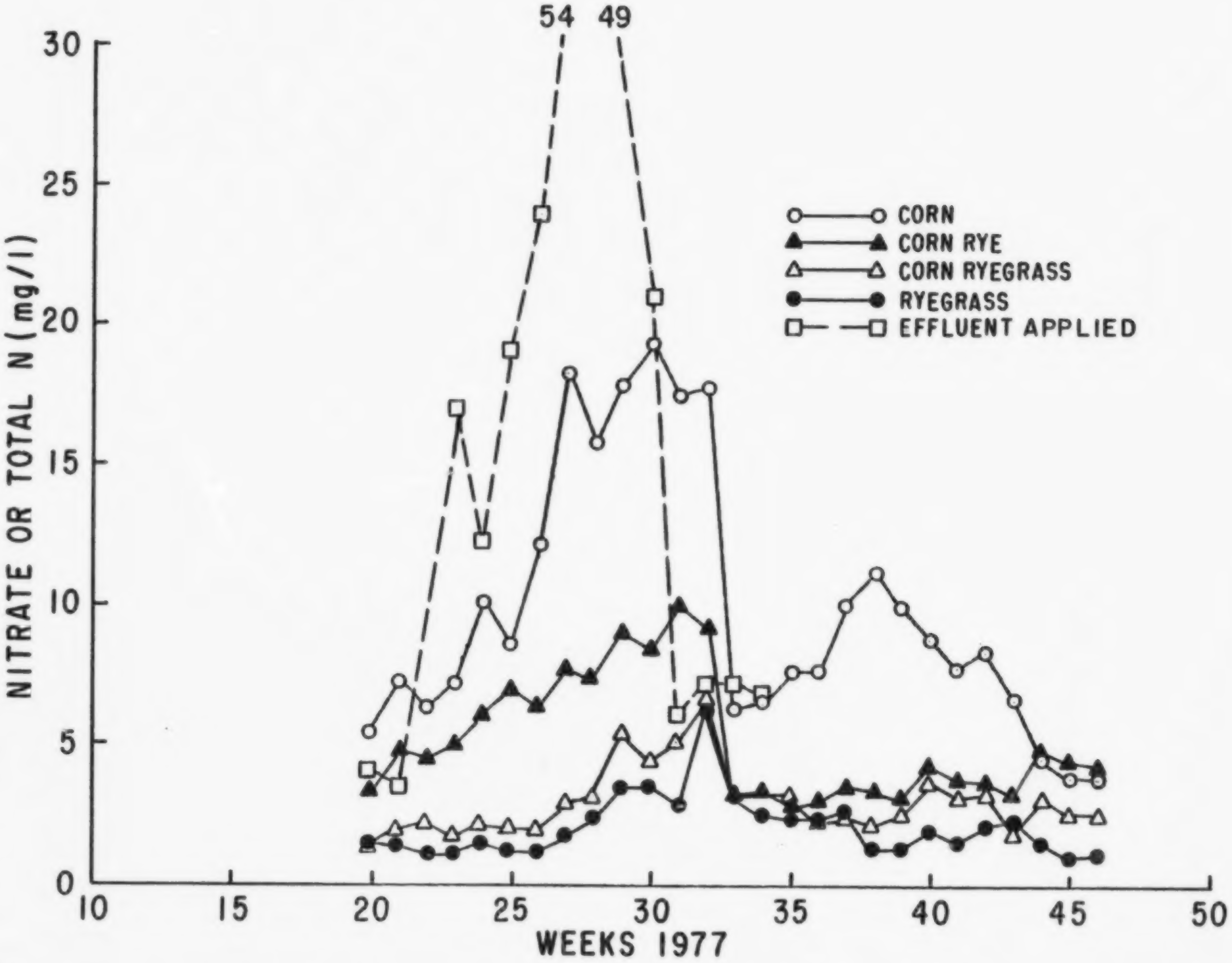

Figure 4. Mean nitrate concentration in 1977 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater.

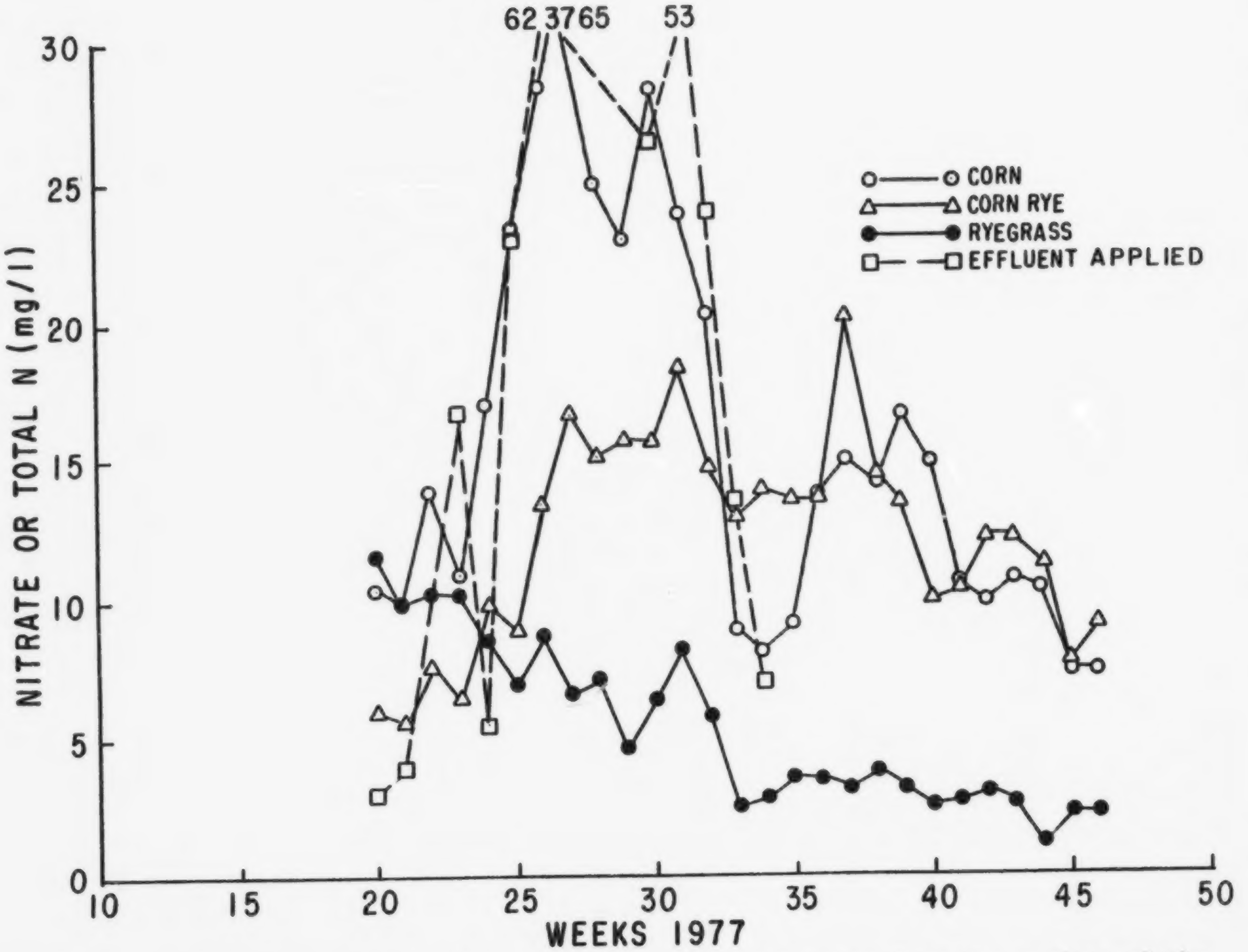

Figure 5. Mean nitrate concentration in 1977 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied high N wastewater.

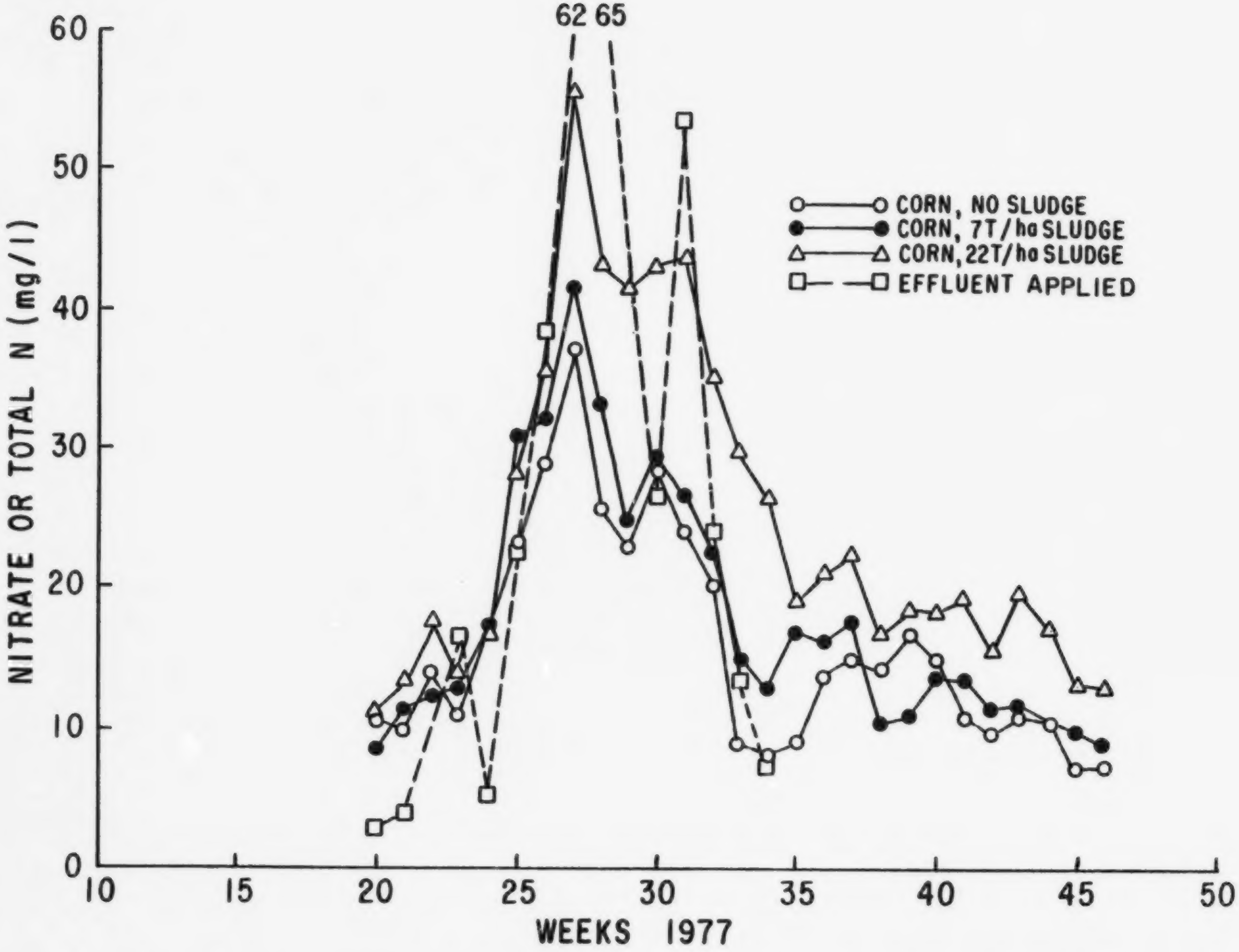

Figure 6. Mean nitrate concentrations in 1977 well water samples from the surface of the water table below various sludge amended corn treatments and total N concentration of the applied high N wastewater.

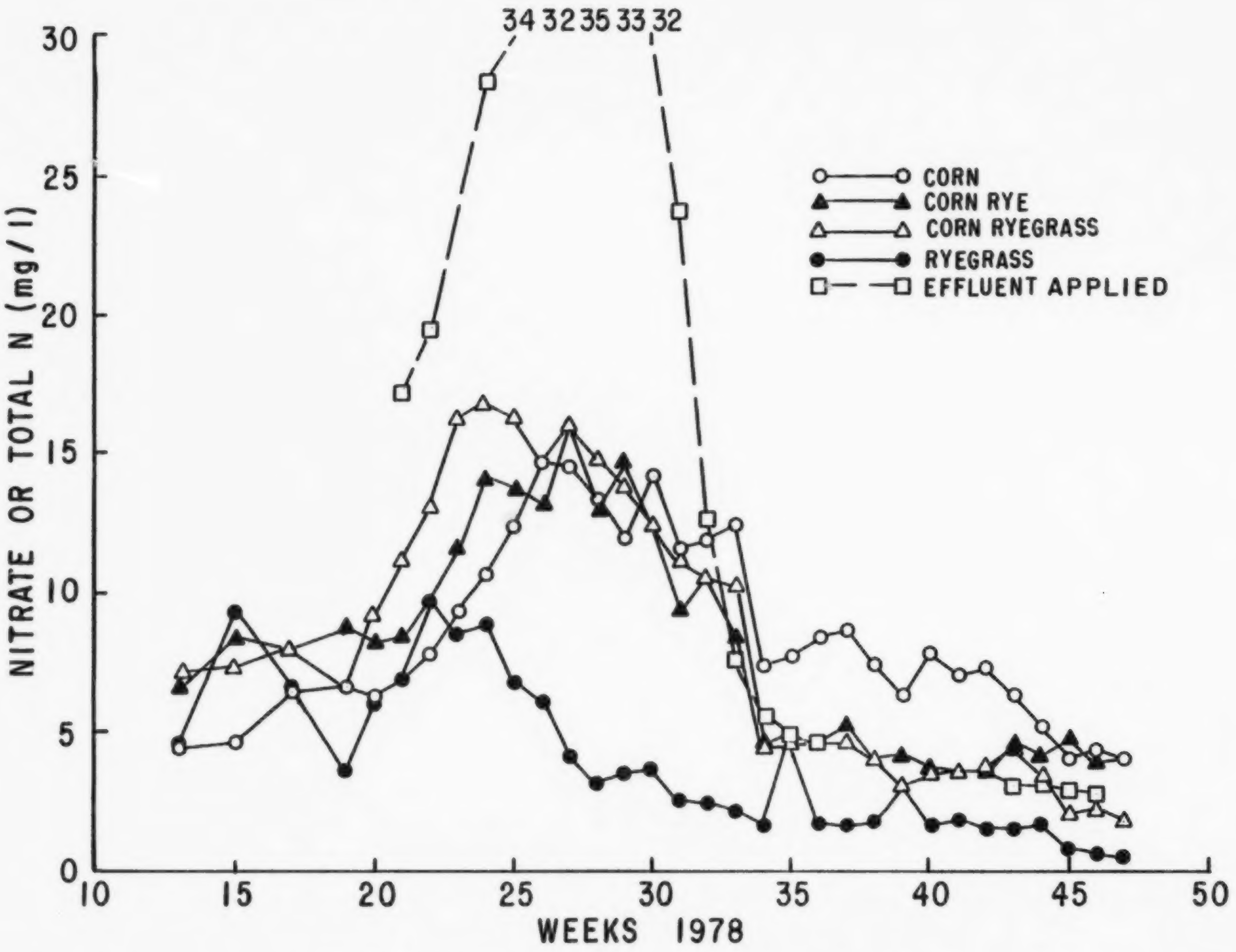

Figure 7. Mean nitrate concentration in 1978 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied low N wastewater.

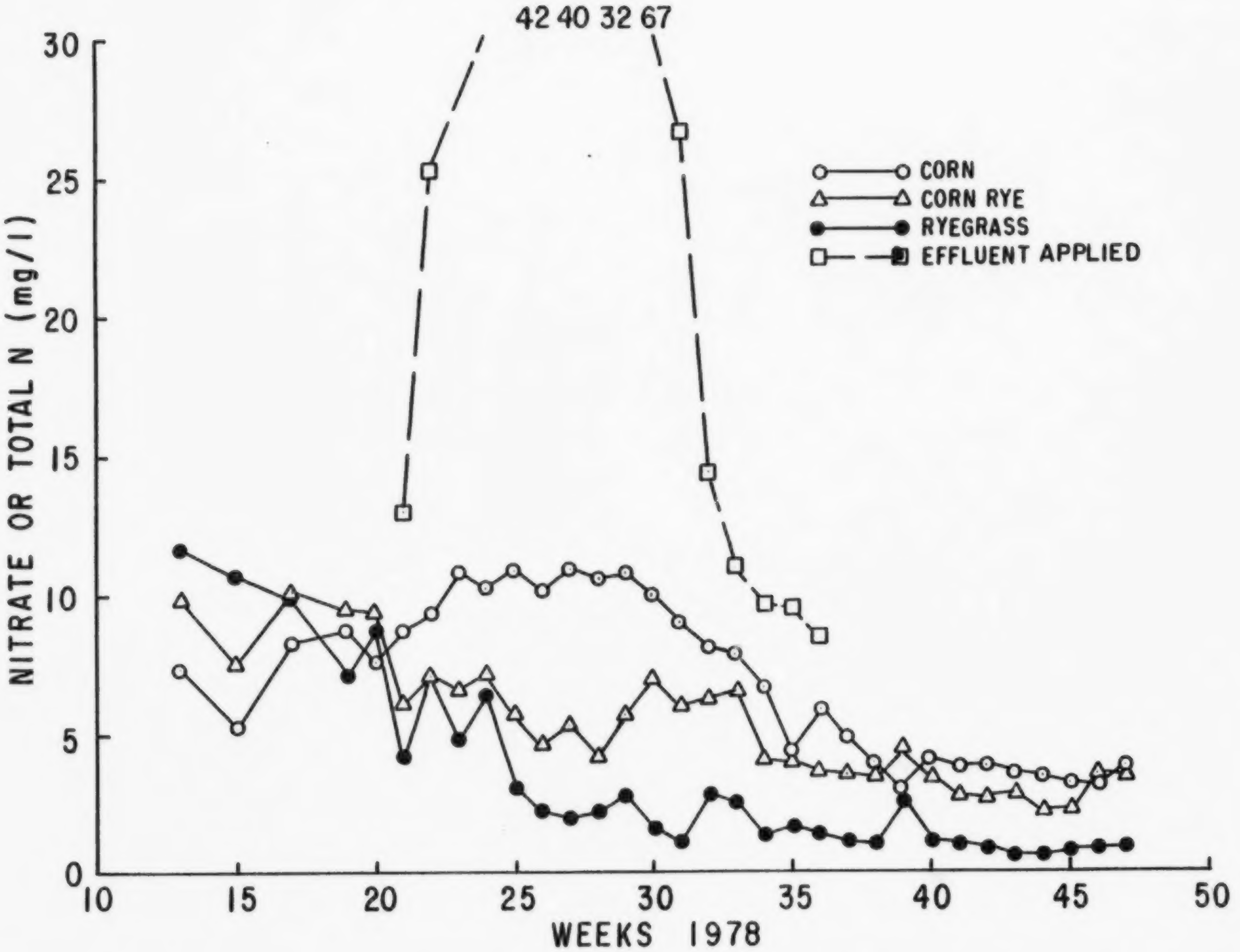

Figure 8. Mean nitrate concentration in 1978 well water samples from the surface of the water table below various crop treatments and total N concentration of the applied high N wastewater.

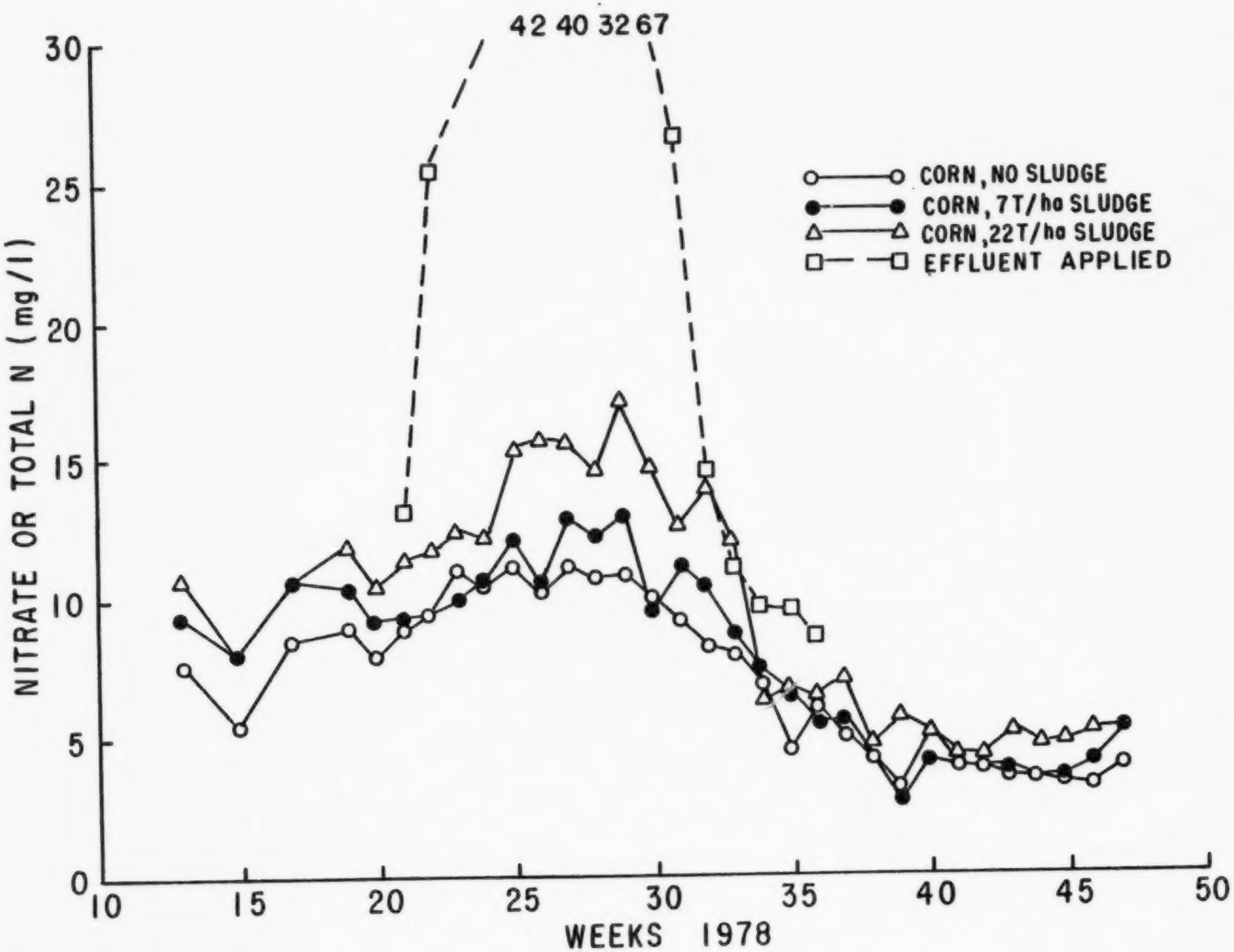

Figure 9. Mean nitrate concentration in 1978 well water samples from the surface of the water table below various sludge amended corn treatments and total N concentration of the applied high N wastewater.

produce an acceptable corn crop. On the high N side of the experiment similar data were obtained with the intercropping compared to corn alone (Figure 5). Sludge was shown to increase the concentration of NO_3-N in the well samples (Figure 6) and would not be an acceptable practice unless very small amounts of sludge were used.

The 1978 data is graphed in Figures 7 to 9. The low N experiment (Figure 7) shows the affect of the overkill of the intercrop by the herbicide which was spread on a windy day. An effective strip of rye was not left; consequently, this treatment differed little from corn alone. The system that was developed to protect a strip of forage between the corn rows would need to be modified if it were to be used under adverse conditions. There was an early release of NO_3 and a period when there was little difference between treatments. The poor drainage conditions on the high N side (Figure 8) masked much of the difference although the cropping systems showed the same relative trends as the year before and the 22 T/ha sludge treatment (Figure 9) continued to have the highest NO_3 level in the well water.

Effect of Sludge Application on Nitrate Leaching--

In 1977 the N-stripping sludge plots were established using sludge additions of 7 and 22 T/ha in the area irrigated with high N wastewater. These plots had corn as the crop and were thus directly comparable to the corn alone treatment. The NO_3 content of the surface layer of the corn alone was moderately high early in the season (Table 7). The 7 T/ha sludge application increased the NO_3 content slightly. But this increase did persist for at least three more weeks (through week 24) before being reduced to a value near the control (corn alone). The 22 T/ha sludge application increased the NO_3 significantly. If a 20% moisture content is assumed this increase is nearly 50 ppm N as NO_3 in solution. Again the increase persisted for three weeks.

The increased levels of NO_3 in the surface soil are reflected in the 15 - 30 cm layers. Both sludge applications had higher values of NO_3 in the subsoil for several weeks. In fact, at the 15-30 cm depth the soil NO_3 on the 22 T/ha treatment was always higher except during the period of mid July to mid August when the corn on these plots, which was the best corn in the experiment, reduced the NO_3 levels to the level of the no sludge corn plots. It appears that immediately after the application of sludge the well aerated conditions that prevailed allowed the readily available N in the sludge to be converted to NO_3 which is readily leached unless the corn is in its rapid growth, maximum demand stage where it can absorb the NO_3 reducing the soil levels to those for corn alone. Because these soils were very infertile, the addition of the array of nutrients in the sludge caused vigorous corn growth on these plots which could reduce the N levels to the same level as on the other plots. It should be pointed out that before and after the period of peak demand there was considerable NO_3 available for leaching from these sludge plots.

TABLE 7. NITRATE CONTENT OF SOILS AS AFFECTED BY SLUDGE APPLICATION AND HIGH N WASTEWATER*

Weeks Averaged	No Sludge	7 T Sludge/ha	22 T Sludge/ha
		ppm N as NO_3 in 0 - 15 cm depth	
19 - 21	15.3	16.8	24.7
22 - 24	12.7	15.4	17.5
25 - 27	12.1	12.6	13.3
28 - 30	12.1	10.3	10.1
		ppm N as NO_3 in 15 - 30 cm depth	
19 - 21	5.1	5.7	7.5
22 - 24	7.7	10.2	13.1
25 - 27	4.8	6.3	7.3
28 - 30	5.1	5.6	6.3

*Corn was grown on all plots.

Plant Tissue

The nutrients in the plant tissue and grain are reported in Appendix Tables A-47 to A-52. The plant tissue nutrient concentrations are quite normal and are similar. The grain nutrient contents are also normal. All nutrients were uniform in the grain except for total N. The corn irrigated with high N wastewater had a slightly higher N concentration in 1977.

Corn Yields

The yields of corn grain and silage (Table 8) are similar to those obtained on similar soils on the Muskegon Wastewater Treatment Facility farm operation. Corn and corn-rye cropping systems produced the same corn grain and silage yield except on the high N in 1977 when oats were used to simulate the overwintering rye. They were too competitive for the corn. The ryegrass intercrop significantly reduced corn grain and silage yields except in 1978 when there was an overkill of the ryegrass to the extent that the N-stripping was impaired. Sludge in 1977 corrected the infertility of this poor soil and gave excellent yields but did add to the NO_3 leaching from the soil.

TABLE 8. YIELDS OF CORN AND SILAGE ON N-STRIPPING EXPERIMENT

Crop	Corn Grain			Corn Silage		
	hl/ha			T/ha		
	1976	1977	1978	1976	1977	1978
Low N Corn	40.6a*	68.9b	53.4a	26.0	26.3b	29.6a
Low N Corn in Rye	42.6a	71.5b	54.1a		25.7b	28.5a
Low N Corn in Ryegrass	23.5b	36.6c	49.8ab	6.4	13.7c	25.4ab
High N Corn		72.5b	35.4abc		25.3b	23.4ab
High N Corn in Rye		42.6c	21.7c		14.3c	14.5b
7T/Ha Sludge on High N Corn		92.5a	32.8bc		35.7a	20.9ab
22T/Ha Sludge on High N Corn		89.1ab	52.7ab		34.7a	27.6a
LSD (.05)		18.8	18.5		8.2	10.6

* Yields with the same letter are not different from others in the same column.

Yield of corn in 1978 was depressed compared to 1977. This may have been the result of too much water on these soils which have a less than perfect drainage system. Drainage is noticeably poorer on the north half of circle 26 which concides with about 50 percent reduction in yields as compared to the south half of the circle.

Corn-rye has proven to be an acceptable N-stripping winter crop without reduction in yield. Corn-ryegrass would need to be controlled better to reduce its competition before it could be advocated.

The supplementary forage experiment demonstrated that all of the forages with the exception of crown vetch can be grown at the Muskegon Wastewater Facility. The crown vetch had difficulty in germination and never became a well established stand. The others were no-till planted to corn in 1978 and the yields are given in Table 9. All of the legumes, rye, ryegrass and the natural quackgrass crops were compatible as an intercrop. Reed canarygrass, tall fescue and orchardgrass formed such a dense root system that the no-till planter was not able to plant in the sod developed on this sandy soil. If these other forages were used they should be tested as to their N stripping abilities.

TABLE 9. CORN YIELDS ON THE SUPPLEMENTARY FORAGE PLOTS IN 1978

Treatment	Corn Yield hl/ha
Red Clover	55.0 a*
Alfalfa	50.1 ab
Birdsfoot Trefoil	45.5 ab
Ryegrass	45.1 ab
Rye	37.4 bc
Quackgrass	34.5 bc
Reed Canary	26.0 cd
Tall Fescue	13.1 d
Orchard Grass	13.0 d
LSD (.05) = 15.4	

* Yields with the same letter are not different from each other.

TABLE 10. ESTIMATE OF N LOSS THROUGH DISCHARGE TO TILE DRAINAGE DURING THE 1977 IRRIGATION SEASON

Treatment		Total N Added	NO_3-N Leached*
		---kg/ha---	
Corn	Low N	209	123
Corn Rye	Low N	209	67
Corn Ryegrass	Low N	209	35
Ryegrass Hay	Low N	209	25
Corn	High N	320	205
Corn-Oats	High N	320	142
Corn 7 T/ha Sludge	High N	547	232
Corn 22 T/ha Sludge	High N	1,033	317
Ryegrass Hay	High N	320	71

* Estimated loss from May 20 to November 20 based upon available meterological data from Muskegon Co. Airport (5/20-7/16) and Circle 26 data (7/16-11/20).

Assumption:
1) The NO_3 concentration of the surface of the water table represents the concentration of NO_3 leaving the root zone
2) There is no loss due to denitrification below the water table surface
3) The water moving the nitrate equals precipitation plus irrigation minus Thornthwaite evapotranspiration
4) There is no net change in water stored

Nutrient Removal

Nutrient removal has been calculated by the amount harvested in the corn crop or the amount of NO_3 leaching into the groundwater and draining away.

The amount of NO_3-N leached from each cropping system is reported in Tables 10 and 11. This is a calculation based on the total N in the wastewater, the NO_3-N concentration in the well water and the amount of water that was applied minus that which would have been evapotranspired. In 1977 the corn alone lost 59 percent of the N applied, while the corn-rye lost 32 percent, ryegrass lost 17 percent and ryegrass alone lost 12 percent when irrigated with low N wastewater. The crops on the high N side did not do as well. The values were 64 percent for corn, 44 percent for corn-rye (oats) and 22 percent for ryegrass. Although the total amount of N added to the sludge plots compared to the amount lost was small, the 22 T/ha sludge treatment lost 50 percent more N to the groundwater than did corn alone. In 1978 (Figure 9) all three corn treatments were similar because of the early herbicide damage but the ryegrass and rye which recovered or was reseeded in August did reduce the leaching losses by 10 percent. The loss from corn alone was only 49 percent that year probably due to increased denitrification resulting from poor drainage. This was an advantage in reducing NO_3-N losses but also reduced the corn yields.

TABLE 11. ESTIMATE OF N LOSS THROUGH DISCHARGE TO TILE DURING THE 1978 IRRIGATION SEASON

Treatment		Total N Added	NO_3-N leached*
		---------------kg/ha	--------------------
Corn	Low N	165	77
Corn-Rye	Low N	165	71
Corn-Ryegrass	Low N	165	70
Ryegrass Hay	Low N	165	30

* Estimated loss from May 22 to November 15 based on evaporation pan data.

Table 12 summarizes the amount of nutrients removed by the corn crop or which could have been removed if silage corn had been removed. Corn grain alone removed from 20 to 50 percent of the total N added in the wastewater.

TABLE 12. AMOUNT OF NUTRIENTS HARVESTED IN CORN GRAIN AND SILAGE FROM THE NITROGEN STRIPPING EXPERIMENT

	Ca		Mg		K		TP		TN	
Crop	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Corn Grain	----------	----------	----------	----------	--kg/ha--	----------	----------	----------	----------	----------
Treatment										
Low N Corn	1.12	.22	7.8	6.0	19	17	16	12	94	74
Low N Corn in Rye	0.97	.29	8.0	7.0	20	19	16	16	96	75
Low N Corn in Ryegrass	.61	.23	4.6	6.7	12	19	9	16	49	67
High N Corn	1.06	.17	9.2	4.1	23	11	14	9	112	49
High N Corn in Rye	.58	.11	4.9	2.6	14	7	9	6	61	30
7T/ha Sludge on High N Corn	1.19	.25	11.2	4.2	28	11	18	11	143	48
22T/ha Sludge on High N Corn	1.28	.29	11.1	6.3	27	17	19	15	147	71
Corn Silage										
Treatment										
Low N Corn	146	66	116	84	1200	453	85	50	831	376
Low N Corn in Rye	159	123	119	96	1240	503	93	76	739	439
Low N Corn in Ryegrass	70	104	49	76	610	527	48	69	357	456
High N Corn	167	57	90	45	1170	431	87	42	763	317
High N Corn in Rye	108	70	59	37	660	241	44	30	414	248
7T/ha Sludge on High N Corn	301	53	131	40	1630	341	141	37	937	291
22T/ha Sludge on High N Corn	308	77	139	53	1450	449	156	59	1125	399

About 50 percent of the total P added in the wastewater was removed by the corn grain. For both N and P far more of the two nutrients were incorporated into the silage than was added in the wastewater. Thus, if corn silage had been removed and shipped away a considerable harvesting of nutrients would have occurred. Corn grain contained relatively small quantities of Ca and Mg (1 to 5 percent of that added in the wastewater) and K removal by grain was intermediate to Ca-Mg and N-P.

METAL CONTAMINATED SLUDGE EXPERIMENT

There are several important questions to be answered about the application of sludge on agricultural land. First, does it have an economic value for agriculture? Second, will the application of sludge alter the crop composition and if it does, will the alteration be beneficial, harmful or unimportant? Third, will the soil transform heavy metals from the sludge into a form that is agriculturally and environmentally acceptable? And finally, will heavy metals from the sludge leach to the groundwater?

Application of sludge to a wastewater treatment system such as the one at Muskegon is considerably different from applying sludge to agricultural lands in a conventional dry land or irrigated production system. First, the soils at Muskegon are very sandy which will provide maximum opportunity for sludge to be decomposed by microorganisms because of well aerated conditions in the soil. Secondly, the water application rate is much higher than in conventional agricultural systems even where irrigation is practiced. Thus, the Muskegon Wastewater Treatment Site allows for evaluation of sludge application to agricultural lands under conditions which would make it most likely to leach nutrients and heavy metals to the groundwater, or put another way, it is an investigation under conditions where problems are most likely to occur.

Nutrient and Heavy Metal Loading Rates

The composition of the sludge used and the calculated soil loading rates on a dry weight basis are given in Table 13. The concentration of all major plant nutrients (N, P, K, Ca, and Mg) would be considered about average for sewage sludges. But, this sludge was high in Cu, Fe, Ni, Cr, and Zn, above average in Cd and Pb, and average Mn.

Nutrient Additions--

Not all of the N and P in sludge is readily available for plants to use, while most of the K, Ca, and Mg would be as available to plants as comparable amounts added by fertilizer or lime applications. For an anaerobically digested sludge taken from drying beds like the sludge used, greater than 80 percent of the total N will likely be in the organic form. Since NH_4-N and NO_3-N were not determined on the sludge, a more accurate estimate of N availability can not be made. If 80 percent organic N in this sludge is assumed, then the amount of N which will be available for plants can be estimated using the methodology suggested by Sommers and Nelson

TABLE 13. SLUDGE ANALYSIS AND HEAVY METAL, NUTRIENT LOADINGS (1976 - 1978)

	N	K	Ca	Mg	P	Cu	Fe	Mn	Cd	Ni	Cr	Pb	Zn
						ppm							
Year of Application													
1976	19,600	2,760	69,800	8,190	22,500	4,450	32,300	450	49	2,520	6,620	1,450	6,670
1977	32,400	2,400	69,300	8,040	14,200	2,920	28,900	180	32	1,770	6,750	610	7,740
1978	27,000	9,780	73,100	5,630	31,200	1,810	54,400	230	37	2,700	4,410	1,270	15,600
Sludge Treatment* (T/ha)						1976 Loadings (kg/ha)							
11	220	30	770	90	250	49	360	5	0.5	28	73	16	73
22	430	61	1,500	180	500	98	710	10	1.1	55	150	32	150
54	1,100	150	3,800	440	1,200	240	1,700	24	2.6	140	360	78	360
99	1,900	270	6,900	810	2,200	440	3,200	44	4.8	250	660	140	660
						1977 Loadings (kg/ha)							
11 + 11	360	26	760	88	160	32	320	2	0.4	19	74	7	86
22 + 22	710	53	1,500	180	310	64	640	4	0.7	39	150	13	170
99 + 81	2,600	190	5,600	650	1,200	240	2,300	14	2.6	140	550	49	630
						1978 Loadings (kg/ha)							
11 + 11 + 11	300	110	800	62	340	20	600	2	0.4	30	48	14	170
22 + 22 + 22	590	220	1,600	120	690	40	1,200	5	0.8	59	97	28	340
99 + 81 +140	3,800	1,400	10,000	790	4,400	250	7,600	32	5.2	380	620	180	2,200

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[*] Treatment designations indicate cumulative loadings for 1977 and 1978 with the second and third numbers, being the rate of sludge application for 1977 and 1978, respectively.

(1976). Based on the total N concentrations in the sludge for 1976-1978 then, 11 T/ha sludge would apply 78 to 131 kg/ha (70-117 lb/acre) available N. This range of N would be the amount recommended for corn yields of about 52 to 104 hl/ha (60-120 bu/acre) in Michigan. Therefore, the 11 T/ha sludge rate would provide adequate N for corn grown on some soils but not on others; the higher sludge rates could be expected to provide excessive N that could result in luxury consumption of N by plants and NO_3 leaching to groundwater.

The situation is somewhat different for P additions. Based on total P in the sludge in 1976-78, and 11 T/ha sludge rate would add 364 to 806 kg/ha (325-710 lb/acre) of P. While not all of the P would be readily available for plants, P fertility levels in the soil could be expected to increase significantly with all the sludge application rates used. The highest sludge rates could be expected to cause a gradual downward movement of P in the soil profile.

As with many sewage sludges, the K added by agronomic rates of this sludge would not be adequate for most cropping programs and supplemental K would be needed. Additions of Ca and Mg from sludge applications at agronomic rates will usually not affect plant growth. Adequate levels of these nutrients will be present in most agricultural soils, although Mg additions are sometimes necessary and could be satisfied by that applied in sludge. The balance of these three nutrients (K, Ca, Mg) in soils is important and can be easily monitored by soil fertility tests. The high additions of Ca and Mg from the high sludge applications could be expected to affect the levels of these nutrients held by the soil and taken up by plants.

Metal Additions--

The quantity of metals added to the soil by the sludge applications were quite substantial, particullarly at the high rates. Maximum metal loadings to agricultural soils have been suggested by a North Central Regional Research Committee (NC-118) (Sommers and Nelson, 1976). For soils having a cation exchange capacity (CEC) less than 5 meq/100 g (like the soils used in this study), the maximum (i.e., lifetime) metal loadings suggested in kg/ha were: Cd--5.6, Ni--56, Cu--140, Zn--280, and Pb--560.

For comparison the amount of metals applied by the 99 T/ha sludge application in 1976 was: Cd--4.8, Ni--250, Cu--440, Zn--660, and Pb--140 kg/ha. The total quantity of metals added to plots retreated with the high sludge rate in 1977 and 1978 was: Cd--12.6, Ni--770, Cu--930, Zn--3,490, and Pb--370 kg/ha. Therefore, plots receiving the highest metal additions (i.e., the "99+81+140" plots) exceeded the suggested maximum by 2-3 times for Cd, 13-14 times for Ni, 6-7 times for Cu, and 12-13 times for Zn. Only about 2/3 of the suggested maximum Pb loading was added.

While the NC-118 researchers expected the suggested lifetime loadings for these five metals to be conservative, the impact of metal loadings at levels which are 6-14 times these suggested maximums are largely unknown.

The effects of the above-indicated metal loadings on plant composition and metal mobility and movement in soils will be discussed.

Yield and Economic Benefit of Sludge

Yield data for corn grain are given in Table 14. The yield response to sludge application in 1976 was marked. Eleven T/ha of sludge increased the yield from 64 to 102 hl/ha (73 to 117 bu/acre). The further yield increase from additional sludge was small and not statistically significant. In 1977, the 11 T/ha application in 1976 had some beneficial carry-over effects but the yield from this treatment was lower than where higher rates of sludge were applied in 1976 or for the 11 T/ha rate applied in 1977. The results were similar in 1978 but both the 11 and 22 T/ha rates of sludge applied in 1976 were low relative to other treatments indicating a gradual decline in nutrient availability as the nutrients were utilized by the crop, leached, or fixed by the soil. As expected the effect was rate dependent.

TABLE 14. GRAIN YIELDS FROM METAL CONTAMINATED SLUDGE STUDY

Treatment	Grain Yield 1976	1977	1978	Average
	- - - - - - - - hl/ha*	- - - - - - - - - -		
No Sludge	64.4b	77.2c	46.4c	62.7
11	101.7a	81.1bc	59.4abc	80.7
11**		96.8ab	70.6ab	83.7
22	107.7a	93.3abc	52.0bc	84.3
22**		99.9ab	73.2a	86.6
54	111.9a	92.0abc	68.2ab	90.7
99	98.5a	93.2abc	74.0a	88.6
99**		100.8a	67.6ab	84.2
L.S.D.	18.9	16.2	17.6	

*Numbers followed by the same letter within a column are not significantly different at the 5% level.

**Annual application (11 + 11 + 11, 22 + 22 + 22, and 99 + 81 + 140 T/ha, respectively).

The economic benefit of sludge applications may be observed by calculating the value of the additional corn produced by the sludge application. For example, 11 T/ha of sludge resulted in an average yield increase of 18.0 hl/ha/year (20.7 bu/acre/year) over the three year period of the experiment. If corn is worth $2.40 per bu, the value of this yield increase over the 4,500 acres of corn produced on the Muskegon Wastewater Treatment System would be $670,680 for the three year period. The value of the increase from 22 and 54 T/ha sludge application would be $803,520 and $1,043,280 respectively. Since it is probable that sludge would be in short supply, the question may be posed "would it be better to apply a low quantity (i.e. 11 T/ha) over a large acreage or apply larger quantities to smaller acreages"? Assuming that there is a uniform cost per T of sludge applied one may calculate the return in each case. The return for 11 T/ha applied to the 4,500 acres is $670,680 as given above; if 22 T/ha are applied to 2,250 acres the return would be $401,760 and it would decrease to $212,520 if 54 T/ha were applied to the corresponding reduced acreage. The conclusion is that the maximum economic benefit would be gained by applying a small quantity of sludge to a larger acreage.

There appeared to be an economic benefit from applying some sludge each year. Although the average yield for a single application of 11 T/ha of sludge was 18 hl/ha, most of the increase came in the first year. The yield increase from residual was 3.9 and 13.0 hl/ha in 1977 and 1978, respectively compared to untreated plots but an annual application of 11 T/ha sludge gave 19.6 and 21.4 hl/ha increase for the years of 1977 and 1978, respectively. This increase is probably due to the added N in the sludge.

N Uptake

The N content of the corn plants (Table 16) at a young stage of growth was not appreciably changed by the addition of sludge. But the dry matter yield (Table 15) was increased by nearly 300 percent (i.e., from 57 to 158 g for 0 and 99 T/ha sludge application, respectively). Such an effect could be expected if the site (or control plot) is severely limited by N during early stages of growth. Under N limiting conditions each increment of N uptake goes to produce additional growth but does not lead to an increased concentration of N in the plant tissue. The level of 2.8 to 3.0 percent of N in tissue is below the expected critical value for corn plants at this stage of growth (Ellis, et al. 1956).

The low availability of N for plant growth is likely due to the fact that most of the applied N was present as organic N which had to be mineralized before the corn could use it. By the second sampling, similar values for the N content were obtained for all treatments except for the high rate of sludge applicatiion where N content in the plants was about 0.5 percent higher than for other sludge treatments. This might indicate that N was no longer limiting plant growth on the high sludge plot. The N content dropped markedly by the third sampling which is normal for corn plants due to a growth dilution effect. However, it must be stressed that the leaf content of N recorded for the second sampling would normally be higher than

TABLE 15. DRY MATTER YIELDS OF SAMPLES FROM SLUDGE PLOTS IN 1976

	SLUDGE RATE (T/ha)				
DATE	0	11	22	54	99
			gms*		
6/10/76	57	54	119	142	158
7/10/76	59	84	92	83	87
8/04/76	1,756	2,440	2,580	2,840	2,260

*The 1st and 3rd samplings consisted of the aerial portion of 10 plants. The second sampling consisted of 20 "ear" leaves and is therefore not sufficient to calculate total dry matter yield.

TABLE 16. N CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
				%		
07/02/76	Plants	2.78	2.99	2.83	2.94	2.81
08/04/76	Plants	2.36	2.50	2.49	2.53	3.06
09/23/76	Plants	0.75	0.78	1.02	0.95	1.00
09/23/76	Grain	1.23	1.30	1.15	1.41	1.36
11/03/76	Grain	1.34	1.38	1.65	1.53	1.55

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/27/76 at dent stage and 11/03/76 at harvest.

the N content of the entire plant. The three higher sludge treatments gave about the same N content in the corn plants at this time which was appreciably greater than for either the control or the 11 T/ha sludge rate. This same pattern persisted in the grain so that corn on the higher three sludge treatments actually removed more total N from the plots than did the control or 11 T/ha sludge treatment. The fraction of the N added in the sludge that was removed with the corn crop was very small. For example, less than 100 kg N/ha was removed by most treatments. But the application rates were 220, 430, 1,100 and 1,900 kg N/ha for the 11, 22, 54 and 99 T/ha sludge respectively.

TABLE 17. EFFECT OF SLUDGE APPLICATION ON RELATIVE UPTAKE OF N, P, K, Ca AND Mg BY CORN.

	SLUDGE APPLIED (T/ha)						
NUTRIENT	11	11*	22	22*	54	99	99*
				%**			
N	98	93	95	94	101	93	94
P	111	122	123	118	127	124	119
K	113	106	89	66	76	73	66
Ca	119	136	124	136	140	157	162
Mg	102	97	98	104	105	112	90

[*] Sludge applied annually (11+11+11, 22+22+22 & 99+81+140, respectively)

[**] Percent relative to the no sludge treatment (control). Each value is the average of 1976, 1977 and 1978 for the first tissue sampling.

The pattern for N uptake by corn plants and N removed in the grain in 1977 and 1978 was similar to that observed in 1976(Table 17). The average N content for the first plant sampling for all three years was between 93 and 101 percent of the control plot. There was no indication that yearly additions of sludge increased the N content of plant tissue although it did increase plant growth.

The N content of the plant tissue is given in Appendix Tables B-14, B-19 and B-20 for 1976, 1977 and 1978, respectively. The N content of corn grain is given in B-14, B-21 and B-22, for 1976, 1977, and 1978, respectively.

P Uptake

The P content of the corn plant (Table 18) was increased by each addition of sludge at each of the first three sampling periods, indicating that P was not the most limiting nutrient in this study. However, the initial level of 0.2 ppm P for the control plot at the first sampling would be considered low for young plants. Phosphorus levels apparently increased by the second sampling indicating that the wastewater and/or sludge was furnishing P in sufficient quantities, although the ear leaf would be expected to contain more P than whole plants. The P content dropped sharply by the third sampling, just as with N, which is expected. The grain P contents were all approximately the same, 0.3 percent, which gave a P removal of about 21 kg/ha for the control and 31 kg/ha for the three high sludge rates. This is only a small fraction of the P added in the sludge since 250, 500, 1,200 and 2,200 kg P/ha were applied in the 11, 22, 54, and 99 T/ha sludge treatments, respectively.

TABLE 18. P CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
		%				
07/02/76	Plants	0.20	0.23	0.26	0.28	0.29
08/04/76	Plants	0.29	0.30	0.31	0.35	0.34
09/23/76	Plants	0.07	0.07	0.08	0.09	0.10
09/23/76	Grain	0.30	0.28	0.28	0.29	0.31
11/03/76	Grain	0.31	0.33	0.31	0.35	0.33

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/03/76 at harvest.

The P content was increased by the sludge addition through all three years of the experiment (Table 17). In general, the increase was from 20 to 30 percent and the addition of sludge each year did not appear to give a further increase showing that the P added had considerable residual effect. These data imply that P removal is largely dependent upon soil factors under these circumstances.

The P content of plant tissue is given in Appendix Tables B-14, B-19 and B-20 for 1976, 1977 and 1978, respectively. The P content of the grain is given in Appendix Tables B-14, B-21 and B-22 for 1976, 1977 and 1978, respectively.

K Uptake

Potassium is an often neglected element in wastewater and sludge studies. And furthermore there is little concern for water contamination with relatively low concentrations of K. The K content of wastewater is usually adequate for plant growth but not excessive. Sludges are usually very low in K because this nutrient is so soluble that it remains with the water fraction during sewage treatment--the K content of the sludge used in this study was quite low, about one tenth of P and N.

The initial value of 4.87 percent K (Table 19) contained in the control plants at the first sampling is normal to high for plants at that stage of growth. There was a trend at the first sampling for the addition of sludge to decrease the content of K in the plants. This decrease was pronounced at the second sampling where the addition of the high rate of sludge decreased the K content of the plants from 1.71 percent for the control to 0.94 with high sludge addition. This effect may be due to two factors: 1) the increase in dry matter production will dilute the K contained in the plant tissue if excess K is present and not limiting the growth of plants; and 2) Na, Mg, and/or Ca contained in the sludge and wastewater may compete with K for plant uptake. Since Na analyses were not included in the sludge experiment, the actual effect of the Na cannot be verified. But Ca and Mg content of the plant tissue did increase markedly as will be seen in the

TABLE 19. K CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
		%				
07/02/76	Plants	4.87	4.92	4.01	4.47	4.26
08/04/76	Plants	1.71	1.72	1.30	1.29	0.94
09/23/76	Plants	1.43	1.30	1.27	1.36	1.02
09/23/76	Grain	0.43	0.36	0.35	0.35	0.37
11/03/76	Grain	0.46	0.42	0.40	0.40	0.38

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest.

next section. The real concern is that the combination of both effects could ultimately produce K deficient plants, particularly in these very sandy soils. This did not appear to be the case since yield was not significantly decreased at the high sludge application rate, but there was some depression in yield in both 1976 and 1978 at the highest sludge application rate. Although the trend to decrease K content of grain with increasing sludge application was present, it was a minor effect.

Average data for the three years is given in Table 17 and all of the data are in Appendix Tables B-14 and B-19 through B-22. The effect of lower K uptake with increasing sludge application was similar and consistent through all years.

Ca and Mg Uptake

The sludge applied contained large quantities of Ca and was at levels about three times greater than P. This, in addition to the Ca contained in the wastewater being applied (approximately 65 ppm Ca), added considerable Ca to the rather acid, Ca deficient soils. The added Ca is reflected in an increase in Ca content of plant tissue (Table 20, B-14, B-19 through B-22). The increases were from 20 to 60 percent on the average (Table 17). When combining this increase with the dry matter increase the total Ca uptake by the plant was increased as much as six fold by the highest sludge additions.

TABLE 20. Ca CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
		%				
07/02/76	Plants	0.41	0.47	0.56	0.68	0.77
08/04/76	Plants	0.30	0.43	0.51	0.59	0.76
09/23/76	Plants	0.29	0.37	0.45	0.50	0.61
09/23/76	Grain	Tr**	Tr	Tr	Tr	Tr
11/03/76	Grain	Tr	Tr	Tr	Tr	Tr

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest.

**Trace was from 20 to 50 ppm or 0.02 to 0.05%.

Little Ca was found in the grain tissue, particularly in 1976. Two different digestion procedures were utilized in 1976 and both gave the same results--about 20 to 50 ppm Ca in the grain tissue. The values in 1977 were up to 200 ppm which is more normal but 1978 again showed low values (less than 100 ppm Ca). This difference is attributed to different corn hybrids being used in the three different years.

The Mg content of the plant tissue (Table 21, B-14 and B19 through B-22) followed trends very similar to those discussed for Ca except that the grain tissue contained a normal quantity of Mg. Although the plant tissue was increased rather markedly in Mg content due to the application of sludge, the grain tissue did not reflect this increase. This trend is not unexpected in that corn normally translocates sufficient nutrients into the grain to produce uniform nutrient content of grain tissue but not an excessive content of any component.

TABLE 21. Mg CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
		%				
07/02/76	Plants	0.25	0.25	0.26	0.32	0.36
08/04/76	Plants	0.15	0.20	0.24	0.30	0.39
09/23/76	Plants	0.21	0.24	0.29	0.31	0.38
09/23/76	Grain	0.03	0.06	0.05	0.06	0.06
11/03/76	Grain	0.06	0.06	0.06	0.06	0.06

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest

Heavy Metal Uptake

The Fe and Mn content of plant tissue were not affected by sludge application. But there was an appreciable decrease in uptake with years over all treatments. The major decrease in Fe content occurred between the first and second sampling in 1976 (i.e. from 662 to 141 ppm for the average Fe content of corn tissue for all treatments for week 27 and 32 of 1976, respectively); whereas, with Mn a decrease occurred each year (i.e. from 83 to 38 to 11 ppm Mn in corn tissue for the first sampling of 1976, 1977 and 1978, respectively). In 1978 the Mn content of the plant tissue was about one-tenth of that in 1976. This reduction in uptake was probably due to an increase in soil pH caused by the application of wastewater. There was still adequate Fe in the plant in 1978 but the Mn content of the plant tissue in 1978 was lower than desired for optimum yields.

The Cu and Zn uptake patterns were similar. Table 22 shows that Cu uptake was increased by sludge application. However, the Cu content of plants grown on the control plots decreased from 1976 to 1978, probably due to the increasing pH of the soil. The same effect was observed but was much more pronounced for Zn. In 1976 the application of sludge increased the Zn content of plants from about 100 ppm to over 300 ppm (Table 23). By 1978 the Zn content of plants grown on the control were about 30 ppm and those from the highest sludge rate were about 100 ppm (Table B-16). This decrease in uptake from 1976 to 1978 could also be accounted for by changing corn hybrids during each of the three years. Different hybrids are known to absorb varying quantities of Zn when grown in the same environment.

TABLE 22. Cu CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

DATE	TISSUE*	SLUDGE RATE (T/ha) 0	11	22	54	99
		ppm				
07/02/76	Plants	13	14	14	15	17
08/04/76	Plants	10	14	16	18	17
09/23/76	Plants	6	8	14	9	10
09/23/76	Grain	ND**	ND	ND	ND	ND
11/03/76	Grain	ND	ND	ND	ND	ND

[*] Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest.

[**] ND (Not Detectable is less than 1 ppm)

Thus, a lower uptake in 1978 may be due to this factor. This explaination could be given for the reduction in uptake for Fe, Mn and Cu as well. But a close examination of the data suggest that corn variety had less effect on uptake of these nutrients than for Zn.

TABLE 23. Zn CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

		SLUDGE RATE (T/ha)				
DATE	TISSUE*	0	11	22	54	99
		ppm				
07/02/76	Plants	90	130	176	223	310
08/04/76	Plants	105	157	178	174	349
09/23/76	Plants	50	82	140	160	261
09/23/76	Grain	20	23	24	26	28
11/03/76	Grain	40	44	49	54	60

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest.

Zinc was the one heavy metal whose content was increased in both the tissue and the grain by sludge application. This is shown in Figure 10 where total Zn applied in the sludge is plotted against Zn content of the tissue or grain. A nearly linear increase in Zn content of both tissue and grain occurred in 1978. The content of the grain was nearly doubled by the highest Zn application (3,490 kg Zn/ha). But it must be noted that the level in the grain would not be considered toxic to either animals or humans.

Copper contents of plants during all years and for all treatments were in a range that would be considered normal. The Zn content of plant tissue from sludge treated plots in the initial year were very high but not high enough to be toxic to either plants or animals. Although there was an increase in the Zn content of the corn grain due to the sludge application, the increase was relatively small compared to the increase in the plant tissue (i.e. about 1.5 times as much Zn in the grain as compared to 3 to 5 times higher in the plant tissue).

The incorporation of Cd into the food chain through use of sludge on agricultural land is of major concern (CAST Report No. 64, 1976). The sludge used in this study was moderate in Cd--12.6 kg/ha of Cd were applied at the heavy sludge application rate in a three year period. The Zn

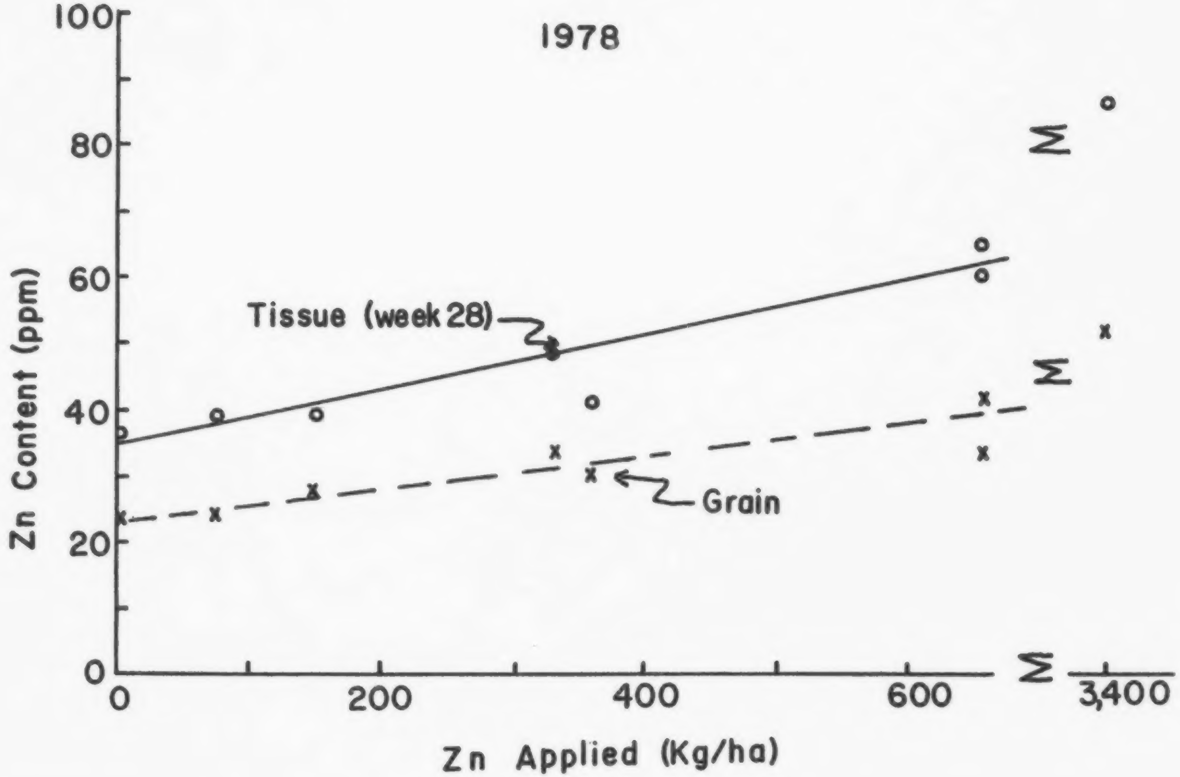

Figure 10. Zinc content of corn tissue and grain grown in 1978 as affected by total Zn applied in sludge.

application from this sludge was more than 100 times the Cd rate. Never-the-less some apparent increase in Cd occurred in the young tissue in 1976 (Table 24). The levels found in tissue in 1976 were near the detection limit of the investigators and were somewhat erratic. No Cd was detected in tissue in 1977 and 1978, and no Cd was detected in the grain in any year indicating that it was not readily translocated from the green tissue to the grain portion of the plant.

TABLE 24. Cd CONTENT OF TISSUE FROM SLUDGE PLOTS IN 1976

DATE	TISSUE*	SLUDGE RATE (T/ha) 0	 11	 22	 54	 99
		ppm				
07/02/76	Plants	0.1	0.3	0.1	0.8	0.9
08/04/76	Plants	ND**	0.4	0.1	0.6	0.8
09/23/76	Plants	0.2	0.8	0.2	0.8	0.5
09/23/76	Grain	ND	ND	ND	ND	ND
11/03/76	Grain	ND	ND	ND	ND	ND

*Whole plants on 7/2/76 and 9/23/76 and ear leaves on 8/4/76; grain on 9/23/76 at dent stage and 11/3/76 at harvest.

**ND (Not Detectable is less than 0.1 ppm)

The data indicate that sludge application did not significantly affect the Pb, Ni, Cr or Hg content of the plant tissue, although an evaluation is difficult since metal concentrations were usually at or below detection limits. Loadings of Pb, Cr and Hg would not be expected to cause increases of these metals in plants because they tend to be very insoluble in soils. In contrast, Ni loadings can more easily cause plant uptake of Ni. But due to competition from other metals or some other factor, increased Ni uptake by corn was not apparent in this study.

Data for heavy metals in the plant tissue are in the Appendix Tables B-13, B-15 and B-16; and corresponding data for the grain is found in Tables B-13, B-17 and B-18.

DTPA Extractable Heavy Metals in Soils

Both DTPA extractable and total heavy metals were followed throughout the three years of the experiment by collecting and analyzing 18 separate soil samplings. The data from these samplings are given in Appendix Tables B-1 through B-3 for DTPA extractable heavy metals and in B-4, B-5 and B-6 for total heavy metals. Obtaining and analyzing samples for total heavy metals was difficult in that digestion of greater than 0.5 g of sample was not possible; consequently, obtaining a representative sample of a soil-sludge mixture that was 0.5 g was not possible and variability for total metal analyses was very large. Ten g samples were extracted for DTPA analysis which gave much more representative samples.

Soil analysis for the surface soil (0 - 15 cm) showed a linear increase in DTPA extractable Zn with Zn applied in the sludge in 1976 (Figure 11). About one-sixth of the Zn applied in the sludge was extracted by the DTPA at the end of the season. The next soil layer (15 - 30 cm) showed an elevated Zn content at the highest Zn application rate. But there was little indication that lower application rates increased the extractable Zn in subsurface soil layers. The extractable Zn in the surface layer decreased considerably by the end of 1977 but did not change appreciably in 1978. Two possible reasons exist for the reduced Zn between 1976 and 1977. First, some Zn was undoubtedly leaching from the surface soil. The fact that Zn levels in the subsoil were elevated under the high treatments shows this. But since subsoil levels were reduced to background by 1978, it is concluded that the fraction that moved from the surface soil also moved out of the profile. This is likely to occur in the acid sandy soils at Muskegon. However, the analysis would make it appear unlikely that leaching could account for all or in fact a major portion of the reduction in Zn extracted from the surface soil. A second possible explanation is that Zn was reverting to insoluble compounds with time. Since the soil pH increased due to the addition of sludge and particularly wastewater, Zn compounds would be expected to precipitate. Although total Zn analyses were variable, they did indicate that the major portion of applied Zn was still present in the surface layer with some increase in the 15 to 30 and 30 to 45 cm layers being noted.

Data for DTPA extractable Cu are summarized in Figure 12. Although the data are more variable than for Zn the trends are similar. About 10 percent of the added Cu was DTPA extractable. Again the Cu level in the subsoil layer was increased by the highest application of sludge during the first year. But Cu did not appear to become less soluble with time as did Zn. This is consistent with the known Cu chemistry in the soil. Copper will remain available for many years in soils once it has been applied and in not so dependent on soil pH as are other heavy metals.

Nickel extracted by DTPA also increased linearly in the surface layer with application rate (Figure 13). The level in the soil decreased with time, particularily at the high levels of applied Ni. Data indicated that Ni was leaching into the soil profile in a manner similar to Zn.

The DTPA extractable levels of other heavy metals were not increased by the addition of sludge which would suggest that they should not be susceptible to leaching or increased plant uptake.

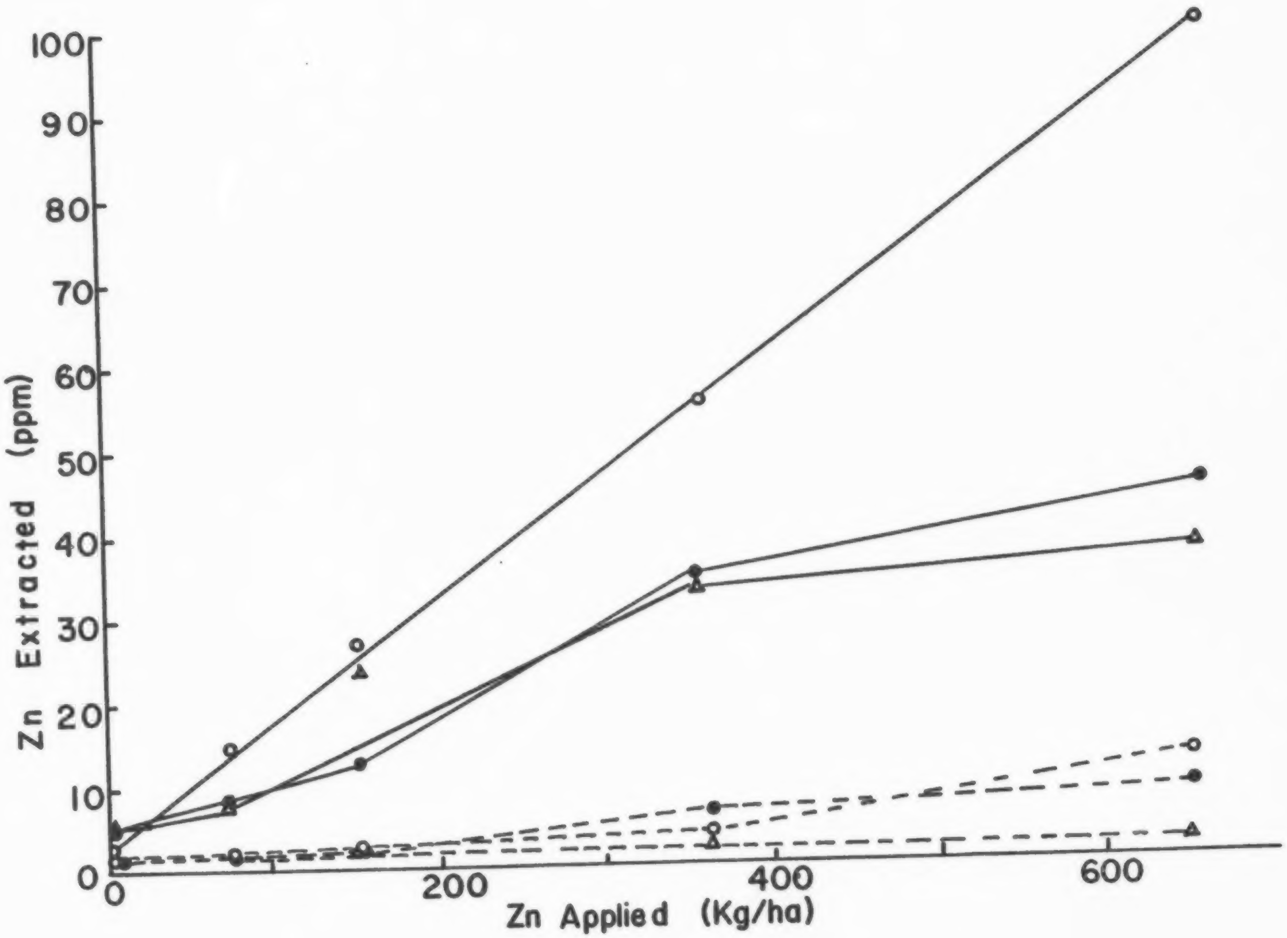

Figure 11. DTPA extractable Zn in soils as affected by Zn applied in sludge in 1976.

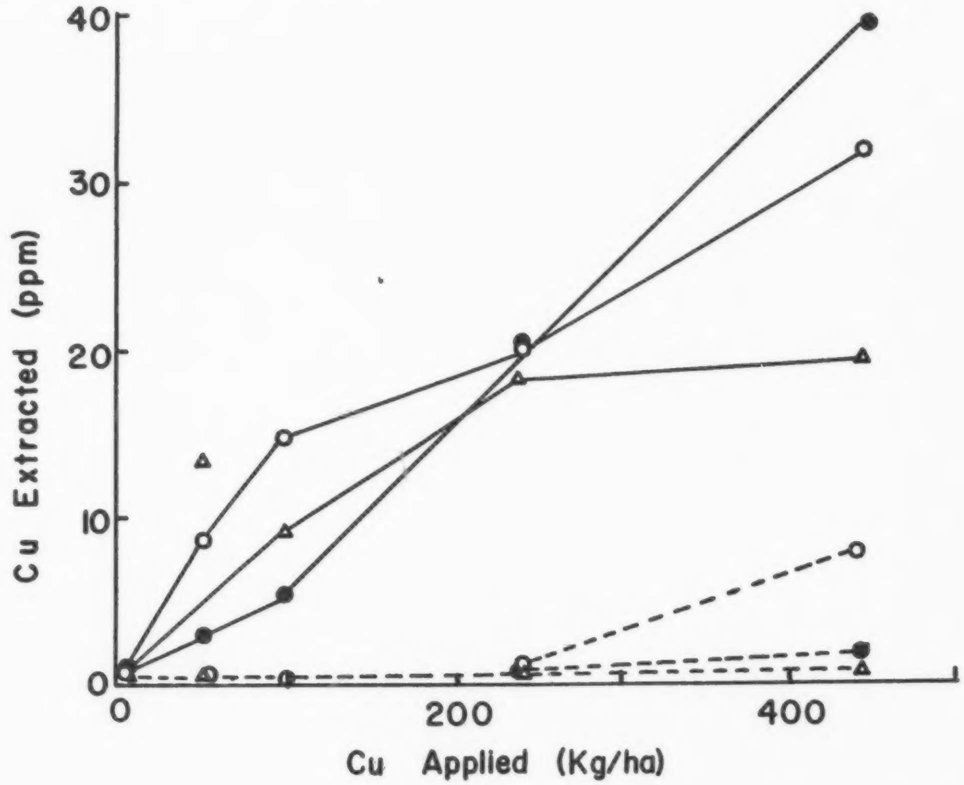

Figure 12. DTPA extractable Cu in soils as affected by Cu applied in sludge in 1976.

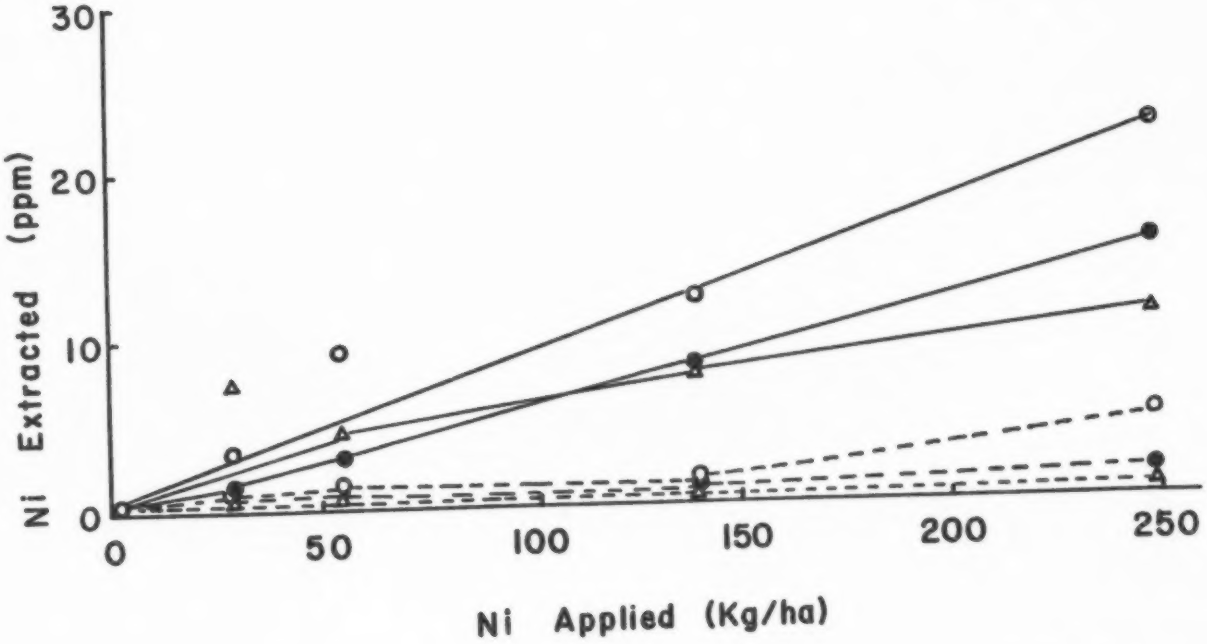

Figure 13. DTPA extractable Ni in soils as affected by Ni applied in sludge in 1976.

Groundwater Analysis

Analysis of the groundwater was not a part of the original design for this study. But samples were collected in the summer of 1978 under the highest sludge application rate (99 + 81 + 140 T/ha) and under the forage-corn treatment of the N-stripping plots to compare the levels of heavy metals in the groundwater under the maximum application of sludge to a treatment that was removed from the area to assure that no contamination existed. The samples of the groundwater were split and one-half of each sample was sent to the Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma and the other portion retained at Michigan State University (MSU) for analysis.

The data from this study are given in Table 25. First, analysis between the two laboratories compared very well for the elements where analyses were above the detection limit of both laboratories. Thus, for Zn, the correlation between the results from the two laboratories was 0.98 and agreement quite good for the average of four replications of the field samples. The correlation for Cu was 0.95 and the samples that did not agree well were below the real detection limit of the MSU laboratory. Agreement was not as good for Ni and Cr. Part of this could be accounted for by the fact that the levels were near the detection limit. But the EPA laboratory did report higher values for both elements where disagreement occurred suggesting a biased error on the part of one of the laboratories for these elements. MSU used HCl digestion while EPA used HNO_3 digestion. This can be the reason for the difference in data.

Clearly Zn has moved into the groundwater as shown by all samplings (July, August and September). Values were approaching one ppm Zn and in fact exceeded this value in August. This result confirms the soil analysis where DTPA extractable Zn was increased by sludge additions and both DTPA extractable and total Zn was found to increase in the subsoil layer with sludge addition. The level of Zn applied to the plots where groundwater samples were collected was 3,490 kg/ha, clearly an exorbitant quantity of Zn to apply under any circumstances. The results would indicate that an undesireable quantity of Zn reaches the groundwater under such high loading rates.

The Cu content of the groundwater was also increased by the high sludge application. But the increase was of the order of a two fold increase if the value in August is not considered (this value will be discussed later). Thus, movement has occurred which agrees with the DTPA extractable soil Cu values but the quantity moving is not excessive even under the high quantity of Cu addition (930 kg/ha).

Like Cu, Ni content of the groundwater also increased under sludge application. The quantity of increase appeared to be intermediate between Cu and Zn. Again, DTPA extractable Ni indicated that movement was occurring.

TABLE 25. COMPARISON OF HEAVY METAL CONTENT OF GROUNDWATER UNDER HIGHEST SLUDGE PLOT AND NO SLUDGE PLOT

Treatment	Date	Heavy Metal										
		Zn		Cu		Ni		Cr		Cd	Pb	Hg
		MSU	EPA	MSU	EPA	MSU	EPA	MSU	EPA	EPA	EPA	EPA
						ppb						
Forage-Corn	July	85 (28)**	68 (13)	44 (10)	27 (8)	43 (11)	16 (1)	21 (6)	18 (3)	2 (2)	21 (4)	ND
	Aug.	103 (9)	131 (93)	40 (13)	46 (18)	29 (12)	27 (17)	15 (13)	33 (27)	<1	26 (16)	ND
	Sept.	91 (14)	96 (10)	46 (4)	44 (5)	33 (14)	17 (9)	13 (6)	16 (3)	<1	12 (4)	ND
Corn Sludge*	July	708 (368)	715 (355)	68 (23)	70 (16)	64 (15)	94 (45)	18 (8)	29 (12)	2 (0.5)	26 (14)	ND
	Aug.	1,130 (573)	1,220 (594)	191 (121)	229 (134)	88 (27)	183 (42)	116 (143)	360 (300)	4.3 (1.5)	97 (73)	ND
	Sept.	639 (235)	682 (143)	99 (25)	109 (33)	62 (22)	96 (30)	62 (81)	100 (97)	2.8 (0.5)	39 (22)	ND

*Sludge applied was 99, 81 and 140 T/ha in 1976, 1977 and 1978, respectively.

**( )gives the standard deviation between replications of the same treatment.

No detectable Hg was found in the groundwater at any time. Increases of Cr, Cd and Pb may have occurred but the great variation between replications made this less certain. Central to this problem was the very high values recorded in August under the sludge treatment. Particularly one sample (plot S23) was very high in all metals. There appeared to be little selectivity between metals suggesting possible surface contamination. If the August sampling is not included, the conclusion is that Cr in the groundwater may have increased but Cd and Pb were not significantly increased by the high application of sludge.

Effect of Sludge on Bases and Soil Reaction

Soil pH values for the sludge treatments are given in Table 26. Soil pH increased with time but this affect was produced both by the sludge application and by wastewater application (wastewater pH was about 7.4). Thus, the pH in 1978 without sludge had increased from 5.3 to 7.0 with the highest application of sludge. The long term effect of sludge in this case is probably less important since the equilibirum pH is expected to reach that of the wastewater, given ample time. If sludge were applied to agricultural areas that were not irrigated an appreciable increase in soil pH would be expected with high application of sludge.

The principal base to be increased during the experiment was Ca (Appendix Tables B-10 through B-12). The control plot increased from 446 to about 820 kg Ca/ha and the highest rate of sludge application gave a final value of more than 1,600 kg Ca/ha. Both the sludge and the wastewater contained large quantities of Ca (Table 13); consequently, the accumulation can not be attributed to sludge application alone. Other bases changed very little during the course of the study even though they were added in the sludge and also in the wastewater. This occurs because of the competition with Ca for exchange sites. Thus, all bases including Ca are expected to leach in these very sandy soils. After addition of sludge the sum of the bases would exceed the cation exchange capacity(CEC) of the soil but as time progressed this value came near to the CEC indicating that levels of bases greater than the CEC were temporary. The K content of the soil was relatively low but did not appear to be limiting crop growth. The K content of the wastewater may be supplying adequate K for the corn crop but the competition of K with Ca for exchange sites would suggest that careful attention should be paid to this nutrient in systems similar to Muskegon.

Although pH increased with sludge and wastewater application, the drive in nature is for soils to become acid. Thus, if and when application of wastewater and sludge is stopped, the pH of the soil will began to drift to more acid conditions. As the soils become more acid heavy metals will become more soluble and available for plant uptake and leaching. Therefore, long-term management of sites receiving sludge must include pH control.

TABLE 26. SOIL REACTION FROM METAL-COMTAMINATED SLUDGE PLOTS

Date	Depth	Sludge Rate (T/ha)							
		0	11	11*	22	22*	54	99	99*
	cm				pH**				
1976 W24#	0–15	5.3(0.3)**	5.5(0.5)		5.3(0.4)		5.7(0.4)	5.9(0.4)	
	15–30	5.1(0.5)	5.0(0.2)		5.1(0.3)		5.0(0.2)	5.1(0.6)	
1977 W21	0–15	6.1(0.5)	6.1(0.5)	6.2(0.3)	5.9(0.2)	6.1(0.3)	6.8(0.7)	6.6(0.2)	6.8(0.2)
	15–30	5.7(0.5)	5.6(0.2)	5.7(0.3)	5.5(0.5)	5.3(0.2)	5.8(0.2)	5.3(0.1)	5.3(0.2)
1978 W21	0–15	6.4(0.2)	6.8(0.4)	6.8(0.2)	6.5(0.3)	6.8(0.1)	6.9(0.2)	6.9(0.3)	6.9(0.3)
	15–30	6.2(0.2)	6.5(0.7)	6.3(0.1)	6.1(0.2)	6.1(0.0)	6.4(0.4)	6.2(0.3)	6.4(0.4)
1978 W46	0–15	6.5(0.1)	6.8(0.4)	6.6(0.3)	6.7(0.2)	6.9(0.4)	7.0(0.3)	6.9(0.4)	7.0(0.3)
	15–30	6.0(0.1)	6.5(0.5)	6.0(0.9)	6.1(0.4)	6.0(0.6)	6.6(0.3)	6.3(0.7)	6.4(0.5)

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[*] Annual application (11+ 11 + 11, 22 + 22 + 22, and 99 + 81 140 T/ha, respectively).

[**] Each value is a mean of four replications; standard deviation is given by ( ).

[#] Denotes week of the calendar year.

Soluble Salts

Soluble salt content of soils is estimated by measuring specific conduction of soils. The values given in Table 27 have been corrected to 30 percent moisture in the soil (saturation percentage for this soil). The addition of sludge increased the soluble salt content of both the surface and subsoil layers during the first year after addition of sludge (Table 27). But the major effect was shortly after the addition of sludge and the soil conductivity decreased with time. It is expected that this is largely the Cl salts of Na, K, Ca and Mg with the monovalent Na and K more susceptible to movement. These salt levels decreased rapidly with time undoubtedly due to leaching. There was no apparent effect of the salt on plant growth in this study but the specific conductance readings immediately after addition of sludge in 1977 and 1978 were sufficiently high to cause some concern. Since this site is irrigated with wastewater the soluble salts were probably quickly moved out of the profile and thus lessened the effect on plant growth.

The conclusion may not be drawn that there is no salt hazard from the addition of sludge. But rather, if the area is not irrigated the hazard may be to agronomic crops and crop selection would need to be compatible with the soluble salt content of the soil and if the area is irrigated the salts will be displaced into the water system. This effect on the ground water, rivers or lakes would need to be evaluated.

Effect of Sludge Application of Soil Properties

Cation Exchange Capacity--

Well decomposed organic matter or humus possesses a high CEC (generally assumed to be 200 milliequivalents (me)/100 g of humus). The addition of rather large quantities of sludge might then be expected to improve the very sandy soils at Muskegon by increasing their CEC. But the measured effect was very small (Appendix Tables B-10 through B-12) and the variably within years and between years was so great that a firm conclusion cannot be drawn. The trend was for a 10 to 20 percent increase in CEC with the highest application of sludge.

Pore Space and Bulk Density--

Organic matter is effective in improving soil structure by binding clay particles together. Thus, the use of high rates of sludge might be expected to improve the water holding capacity and the air-water relations of the soil, and to reduce the bulk density. However, the very sandy soils at Muskegon are principally of a single-grained structure. Under these conditions sludge application had little or no effect on the pore space distribution as measured by water retention (Tables 28 and 29).

Bulk density did appear to become slightly lower with addition of high levels of sludge. This difference was consistent between 1976 and 1978 but represented less than 10 percent change at the highest levels of sludge application.

TABLE 27. SPECIFIC CONDUCTANCE OF METAL-CONTAMINATED SLUDGE PLOTS

Date	Depth	Sludge Rate (T/ha)							
		0	11	11*	22	22*	54	99	99*
	cm				umhos**				
1976 W24#	0-15	1,006	1,350		1,520		1,800	2,600	
	15-30	640	760		1,030		1,260	1,690	
1976 W45	0-15	650	710		770		930	1,320	
	15-30	540	660		780		840	980	
1977 W21	0-15	2,028	2,534	2,601	1,941	3,534	2,327	3,273	6,558
	15-30	1,170	1,220	1,269	1,493	1,381	1,170	1,257	2,042
1977 W47	0-15	851	1,307	1,144	944	1,264	1,6321	1,622	2,042
	15-30	711	476	804	733	746	6387	701	1,116
1978 W21	0-15	1,115	1,088	1,777	996	1,986	1,192	1,454	3,609
	15-30	819	871	1,001	864	1,073	1,038	961	1,969
1978 W46	0-15	1,046	1,239	1,410	1,066	1,295	1,091	1,290	2,211
	15-30	950	970	1,153	852	983	785	1,050	1,675

*Annual application (11+ 11 + 11, 22 + 22 + 22, and 99 + 81 140 T/ha, respectively).

**Each value is a mean of four replications.

#Denotes week of the calendar year.

TABLE 28. PHYSICAL PROPERTIES OF THE SLUDGE AMENDED SOILS (1976)

Parameter	Sludge Rate (T/ha)				
	0	11	22	54	99
			%		
Pore Space	49.8	48.6	49.9	50.2	49.5
Water retained at 0.01 Bars	45.4	44.4	45.1	43.2	43.6
0.02 Bars	43.2	42.5	42.6	41.0	40.2
0.03 Bars	38.3	38.0	38.2	34.2	35.2
0.04 Bars	34.8	35.2	36.3	30.3	32.4
0.06 Bars	29.9	29.8	28.8	28.8	28.3
0.10 Bars	27.7	27.5	25.8	26.6	25.0
0.33 Bars	24.0	24.4	23.6	23.1	22.2
1.00 Bars	22.1	20.8	22.8	20.7	21.1
Bulk Density in g/cc	1.50	1.50	1.51	1.48	1.43

TABLE 29. PHYSICAL PROPERTIES OF THE SLUDGE AMENDED SOILS (1978)

Parameter	Sludge Rate (T/ha)							
	0	11	11*	22	22*	54	99	99*
					%			
Pore Space	48.1	49.5	49.3	46.7	46.1	46.5	48.4	50.7
Water retained at 0.01 Bars	44.1	44.8	45.5	42.0	42.0	41.9	43.4	46.9
0.02 Bars	41.7	42.0	43.7	39.3	40.0	38.4	40.5	43.9
0.03 Bars	39.1	39.5	40.2	36.1	37.4	35.5	37.7	41.0
0.04 Bars	36.1	37.5	37.7	33.2	35.3	32.5	35.2	38.9
0.06 Bars	34.3	35.7	36.1	31.4	33.8	29.7	33.3	38.5
0.10 Bars	28.8	29.4	31.1	25.4	28.4	25.1	28.5	35.0
0.33 Bars	27.1	27.5	29.4	24.1	27.4	23.1	27.1	33.3
1.00 Bars	26.8	26.1	27.3	24.6	24.7	22.5	27.7	30.5
Bulk Density in g/cc	1.50	1.48	1.50	1.56	1.52	1.51	1.45	1.42

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APPENDIX A
DATA FOR N-STRIPPING STUDIES

TABLE A-1. WEEKLY AVERAGES OF WASTEWATER CONSTITUENTS APPLIED TO LOW N PLOTS IN 1976

Week	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	ppm										µ/mhos	
21	2.9	0.45	1.66	4.56	170	1.57	1.10	9.6	63.6	12.5	780	8.33
22	3.4	0.25	3.32	6.72	196	1.58	1.43	9.2	45.4	9.9	780	8.42
23	3.3	1.36	6.80	10.10	250	2.12	2.40	11.4	73.0	15.9	980	8.46
24	2.4	2.97	10.68	13.08	373	2.29	2.47	14.4	69.6	15.8	1300	8.56
25	1.3	2.42	10.38	11.68	272	2.48	2.80	10.6	62.2	12.7	960	8.38
26	2.5	5.01	11.93	14.43	207	2.50	2.59	10.3	62.5	12.7	1070	7.88
27	3.1	6.16	16.16	19.26	267	2.63	2.97	11.9	75.5	14.8	1280	8.06
28	6.3	3.22	14.73	21.03	212	2.58	2.69	11.4	78.9	17.5	1200	7.86
29	5.3	4.98	16.66	21.96	193	2.61	2.30	10.1	66.7	14.1	1010	7.88
30	4.1	5.38	15.65	19.75	168	2.86	3.23	9.3	81.4	13.9	1030	7.78
31	3.6	5.08	15.42	19.02	176	2.41	2.46	10.3	82.8	16.0	1020	7.87
32	3.3	4.45	12.03	15.33	248	2.63	2.12	11.9	53.4	13.5	1030	7.95
33	1.1	1.27	5.09	6.19	238	1.86	2.07	9.7	63.7	14.8	1110	7.90
34	2.8	1.49	5.96	8.76	268	2.03	2.49	9.3	53.4	17.3	1170	7.98
35	4.5	5.99	5.99	10.49	264	2.07	2.38	9.6	57.1	15.8	1100	7.97
36	16.0	1.38	5.86	21.86	306	1.67	1.93	13.0	60.2	13.0	1180	8.30
37	21.6	1.38	5.27	26.87	275	1.52	1.65	13.2	64.6	14.6	1130	8.33
Avg.	5.1	3.13	9.62	14.48	240	2.20	2.30	10.9	65.5	14.4	1070	8.11
Std. Dev.	5.4	2.04	4.96	6.05	54	0.44	0.54	1.6	10.4	1.9	150	0.26

TABLE A-2. WEEKLY AVERAGES OF WASTEWATER CONSTITUENTS APPLIED TO LOW N PLOTS IN 1977

Week	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	ppm										µ/mhos	
20	2.00	4.71	2.15	4.15	321	1.80	1.90	17.7	70.2	12.6	810	7.55
21	1.13	3.77	2.51	3.64	270	1.90	1.97	12.1	61.8	12.7	840	7.84
23	4.60	6.18	12.45	17.05	445	2.00	2.00	12.3	68.1	12.5	940	8.08
24	5.00	8.88	18.80	23.80	477	2.00	2.10	12.2	73.1	12.7	970	7.89
25	3.00	7.06	16.08	19.08	291	2.10	2.10	10.3	74.5	13.5	1140	8.20
26	4.53	8.67	19.45	23.98	237	2.28	2.33	10.3	74.4	18.5	820	7.94
27	22.00	17.30	31.90	53.90	208	2.40	1.50	10.7	83.2	19.3	1010	7.30
28	16.10	12.07	32.90	49.00	300	2.60	2.40	10.9	81.0	18.5	1190	7.56
30	4.70	5.04	16.40	21.10	238	2.40	2.50	11.0	79.2	17.8	1250	7.34
31	0.80	2.12	5.43	6.23	207	2.50	3.00	9.1	83.8	19.0	990	8.01
32	0.40	2.86	6.64	7.04	239	2.25	2.35	10.8	66.8	38.9	800	7.47
33	0.20	3.04	7.01	7.21	245	2.30	2.25	9.5	69.1	36.9	830	7.82
34	1.67	1.88	5.26	6.93	240	2.30	3.20	9.5	64.2	24.7	1100	7.55
43	1.30	4.70	9.87	11.17	254	2.25	2.30	9.8	58.4	18.1	870	7.84
44	0.86	4.65	8.29	9.15	263	2.48	2.62	9.5	57.5	18.4	1040	7.64
45	0.13	3.08	6.19	6.32	252	2.33	2.50	9.4	57.1	18.1	1020	7.62
Avg.	4.28	6.00	12.58	16.86	280	2.24	2.31	10.9	70.2	19.5	980	7.73
Std. Dev.	6.11	4.09	9.48	15.20	77	0.23	0.41	2.1	8.9	7.9	140	0.26

TABLE A-3. WEEKLY AVERAGES OF WASTEWATER CONSTITUENTS APPLIED TO HIGH N PLOTS IN 1977

Week	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	ppm										μ/mhos	
20	1.10	3.70	1.95	3.05	312	1.90	2.20	10.7	66.0	12.2	840	7.72
21	1.25	3.57	2.73	3.98	277	1.90	1.80	12.6	66.7	12.6	860	7.83
23	6.30	5.05	10.54	16.84	352	1.95	1.70	12.5	65.0	12.7	920	7.70
24	0.80	2.56	4.44	5.24	465	2.00	2.00	12.5	63.9	12.3	930	7.73
25	3.85	7.85	19.23	23.08	241	2.13	2.15	10.2	72.5	14.2	1040	8.10
26	7.60	13.87	30.70	38.30	234	2.33	2.40	10.4	72.3	18.0	950	7.99
27	23.73	20.57	38.11	61.84	297	2.47	2.33	10.8	77.3	17.4	1270	7.10
28	18.73	16.28	46.50	65.23	263	2.63	2.70	11.4	84.0	19.2	990	7.74
30	7.40	7.09	18.99	26.39	213	2.25	2.40	10.6	83.6	19.0	1180	7.52
31	11.20	18.68	42.18	53.38	207	2.45	3.00	10.8	80.4	19.4	1100	7.78
32	4.50	7.78	19.57	24.07	251	2.30	2.30	9.4	67.6	36.4	840	7.99
33	1.65	4.45	11.80	13.45	248	2.25	2.20	9.6	69.2	37.8	800	7.82
34	0.40	2.91	6.97	7.37	209	2.30	5.00	9.8	69.7	37.3	1070	8.21
43	2.70	4.62	17.02	19.72	254	2.20	2.40	10.1	58.1	18.5	900	7.85
44	3.45	8.58	15.81	19.26	270	2.30	2.50	9.7	57.1	17.9	940	7.37
45	1.50	9.02	10.05	11.55	248	2.15	2.25	9.5	52.1	18.0	1030	7.68
Avg.	6.01	8.54	18.54	24.55	271	2.22	2.46	10.7	69.1	20.2	980	7.76
Std. Dev.	6.72	5.77	13.96	20.05	64	0.21	0.75	1.1	9.2	8.8	130	0.27

TABLE A-4. WEEKLY AVERAGES OF WASTEWATER CONSTITUENTS APPLIED TO LOW N PLOTS IN 1978

Week	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	----------	----------	----------	----------	---ppm---	----------	----------	----------	----------	----------	µ/mhos	
21	1.59	4.50	15.56	17.15	235	1.74	2.49	10.6	73.6	14.0	1140	7.47
22	0.00	2.09	19.45	19.45	190	1.74	2.59	11.0	75.7	14.4	1050	7.43
23	0.00	3.52	6.48	6.48	194	1.81	2.59	10.5	75.8	15.1	910	7.59
24	4.77	15.56	23.66	28.43	176	1.82	2.08	19.0	76.3	13.9	1190	7.84
26	5.91	17.51	28.52	34.43	171	1.93	1.73	20.6	69.7	13.0	1120	7.99
27	5.74	14.04	26.15	31.89	173	1.83	1.75	20.4	75.0	13.4	1240	7.99
28	6.85	14.59	28.09	34.94	171	1.71	1.77	19.4	81.5	14.8	1240	8.01
29	7.73	11.31	25.12	32.85	182	1.71	1.81	21.3	112.2	16.6	1190	7.98
30	7.13	12.64	25.12	32.25	205	1.77	1.86	18.8	133.3	14.7	1190	7.87
31	6.64	8.51	17.02	23.69	191	1.76	1.82	19.0	118.6	15.6	1230	7.77
32	4.48	4.72	8.12	12.60	190	1.74	1.80	18.3	117.0	16.1	1110	7.71
33	5.22	0.68	2.36	7.58	175	1.75	1.67	18.2	108.5	14.8	1020	7.68
34	3.17	0.29	2.42	5.59	175	1.35	1.51	16.3	73.2	15.7	950	8.10
35	2.70	0.07	2.20	4.90	173	1.48	1.49	16.9	73.2	15.7	950	8.20
42	1.27	0.15	2.35	3.62	168	1.23	1.16	9.1	73.2	16.0	950	7.08
43	0.97	0.17	2.13	3.10	179	1.13	0.88	9.2	74.8	15.2	1010	7.48
44	0.99	0.21	2.15	3.14	178	1.04	0.91	9.4	77.1	14.4	970	7.40
45	7.14	0.25	2.02	9.16	182	1.32	1.09	9.5	82.2	15.2	1220	7.60
46	0.89	0.20	1.98	2.87	137	1.00	0.95	7.0	73.3	11.0	800	7.99
Avg.	3.85	5.84	12.68	16.53	181	1.58	1.68	15.0	86.5	14.7	1080	7.75
Std. Dev.	2.72	6.37	10.83	12.54	19	0.30	0.53	5.0	20.0	1.3	130	0.29

TABLE A-5. WEEKLY AVERAGES OF WASTEWATER CONSTITUENTS APPLIED TO HIGH N PLOTS IN 1978

Week	NO_3	NH_4	TKN	TN	Cl	PO_4	TP	K	Ca	Mg	Spec. Cond.	pH
	ppm										µ/mohs	
21	0.90	3.58	12.96	13.86	230	1.71	2.22	10.6	73.5	14.0	1170	7.47
22	3.42	8.40	21.88	25.30	196	1.76	2.59	10.7	74.7	14.2	1180	7.55
23	0.00	3.38	1.62	1.62	194	1.76	2.59	11.1	74.2	15.0	910	7.80
24	4.37	13.77	25.93	30.30	176	1.88	2.38	19.2	72.8	13.3	1190	7.80
26	8.47	21.61	33.71	42.18	173	1.87	1.73	21.3	70.8	12.9	1150	8.01
27	8.50	17.83	31.77	40.27	176	2.04	1.75	20.6	77.1	13.7	1180	7.88
28	5.94	14.04	24.85	20.79	167	1.72	1.75	19.4	54.4	10.5	1190	7.97
29	7.38	13.84	24.85	32.23	183	1.69	1.82	22.3	115.5	16.8	1170	7.84
30	7.48	27.65	59.96	67.44	194	1.80	1.88	19.5	121.8	15.0	1290	7.83
31	7.06	10.86	19.45	26.51	188	1.86	1.95	18.7	118.5	15.1	1230	7.69
32	4.59	5.30	9.92	14.51	192	1.76	1.76	18.8	118.5	15.8	1160	7.79
33	8.64	4.55	2.31	10.95	178	1.75	1.78	15.6	114.9	14.3	1090	7.68
34	7.33	4.38	2.32	9.65	160	1.34	1.50	16.8	71.7	15.1	940	7.97
35	6.89	4.40	2.64	9.53	173	1.30	1.59	16.6	77.9	15.7	1000	8.11
36	6.05	0.22	2.57	8.62	151	1.28	1.46	8.0	66.3	14.4	840	7.48
Avg.	5.80	10.25	18.45	24.25	182	1.70	1.92	16.6	86.8	14.4	1110	7.79
Std. Dev.	2.67	7.79	16.24	17.24	19	0.22	0.36	4.5	23.4	1.5	130	0.19

TABLE A-6. NITRATE, AMMONIUM AND CHLORIDE CONTENT OF SOIL SAMPLES FROM LOW N CORN IN 1976

	0-15 cm			15-30 cm			30-45 cm			46-61 cm			61-91 cm			Wells		
Week	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl
	ppm																	
20	1.9	1.8	4.1	1.7	1.1	4.8	1.4	1.0	2.7	1.5	.8	2.8	1.7	.8	2.8			
24	6.9	2.3	11.2	3.6	1.2	3.1	2.5	.8	1.6	1.9	.6	1.4	1.8	.5	1.4	1.7	.8	18.6
25	7.8	2.4	23.2	5.6	1.7	15.6	3.8	1.3	6.4	2.9	1.0	2.9	2.8	.4	2.6	7.5	.1	33.9
26	4.5	2.8	29.9	2.4	2.2	15.9	1.7	1.2	8.7	1.2	.8	5.3	1.1	.5	3.6	5.0	.1	98.5
27	5.4	2.2	29.2	3.6	1.7	19.3	2.4	1.0	14.5	1.7	.8	11.8	1.4	.9	7.6	5.0	.7	65.6
28	6.4	2.5	52.3	3.8	2.8	21.5	2.5	.9	13.1	2.1	1.1	10.7	1.5	.9	7.0	5.3	.7	74.5
29	4.3	1.7	48.2	3.2	1.7	26.5	2.7	1.4	21.0	2.0	.9	13.3	1.6	1.0	11.7	6.2	.6	94.2
30	5.8	1.4	58.4	3.0	1.3	27.7	2.5	.9	22.6	1.7	1.0	20.1	1.4	.4	15.9	8.1	.3	94.3
31	3.5	1.2	45.2	2.2	1.4	29.4	1.9	.9	19.9	2.0	.7	17.4	1.6	.5	15.1	10.1	.4	112.9
32	3.9	1.4	44.1	1.6	1.5	32.7	1.9	1.2	31.7	1.5	.9	22.2	1.4	.8	20.2	10.4	.6	206.0
33	2.2	1.3	36.9	1.4	1.0	27.6	1.2	.8	22.9	1.2	.6	25.7	1.0	.3	17.0	10.4	.6	206.0
34	1.1	1.7	22.1	.9	1.2	21.9	1.1	1.2	22.5	1.0	.8	20.3	1.0	.5	21.0	14.0	.6	192.6
35	.9	1.7	29.4	.5	.9	17.0	.7	1.1	16.7	.6	1.1	13.5	.6	.8	12.5	9.0	.8	212.4
36	.8	1.1	23.7	.6	1.0	16.7	.6	.8	14.4	.7	.7	13.2	.7	.8	11.0			
37	2.8	.5	34.5	1.6	.4	27.5	1.4	.2	16.1	1.2	.2	13.6	1.2	.2	13.1	6.9	.1	225.7
38	2.4	1.5	29.1	1.5	.8	20.1	1.3	.8	14.1	1.4	.9	13.9	1.4	.9	13.8	15.5	.2	182.8
39	1.0	1.7	36.4	.6	1.0	22.1	.6	.8	16.5	.5	1.0	14.0	.6	.6	13.4	8.1	.1	146.9
40	2.1	1.4	27.7	1.4	.9	21.6	1.0	.7	14.4	1.0	.5	12.6	.9	.6	10.8	10.8	.3	155.7
41	2.0	1.6	38.4	1.3	1.2	27.5	1.1	.8	22.7	.9	1.0	17.8	.9	.8	16.8	10.6	.4	199.3
42	2.4	1.2	37.6	1.2	.9	40.5	1.0	.5	29.7	.8	.9	26.0	.8	.7	21.4	10.3	.3	165.8
44	4.8	1.6	55.0	2.9	1.0	41.8	2.0	.8	37.0	1.4	1.1	23.4	1.0	.5	21.4	2.1	.2	109.9
45	3.6	1.5	30.9	2.3	1.2	35.6	1.8	.8	28.5	1.5	.8	25.8	1.1	.7	24.6	2.4	.2	51.8

TABLE A-7. NITRATE, AMMONIUM AND CHLORIDE CONTENT OF SOIL AND WATER SAMPLES FROM LOW N CORN RYEGRASS IN 1976

	0-15 cm			15-30 cm			30-46 cm			46-61 cm			61-91 cm			Wells		
Week	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl
	ppm																	
20	2.5	1.4	4.0	1.8	.8	3.2	1.6	.9	2.4	1.5	.9	1.9	1.4	.6	1.9			
24	8.7	1.8	11.4	3.4	2.2	3.7	2.4	1.0	2.9	2.3	1.0	1.4	2.1	.5	2.0	2.5	.7	38.5
25	5.8	2.8	28.5	3.3	1.6	9.8	2.7	1.0	6.1	2.3	.6	4.7	2.5	.6	3.0	6.0	.2	48.0
26	1.8	3.5	37.1	1.0	2.9	12.6	.9	1.1	8.4	.8	.7	6.1	.8	.8	6.1	4.0	.2	150.2
27	2.5	2.0	32.9	1.3	2.0	18.3	1.1	1.3	14.2	1.0	1.0	11.7	.9	.7	25.1	3.7	.6	102.1
28	1.9	1.7	40.8	.9	1.1	19.4	.9	1.1	13.8	.9	1.4	10.7	1.6	1.0	8.5	3.1	.8	121.6
29	2.1	2.0	52.5	1.4	1.3	23.3	1.1	1.2	16.2	1.2	1.0	15.0	1.2	.9	14.4	2.9	.7	153.8
30	1.8	1.6	62.2	.9	1.3	33.6	.8	.9	20.5	.8	.8	16.6	.6	.6	12.9	2.7	.3	125.2
31	1.5	1.3	67.7	.7	.9	24.6	.9	.6	16.4	.8	.6	13.4	.8	.4	10.7	2.2	.4	135.2
32	1.1	2.1	36.8	.7	1.7	33.6	.7	1.3	32.0	.6	1.1	26.8	.6	1.1	23.9	2.2	.6	164.2
33	.8	1.5	30.7	.5	1.0	24.1	.5	.6	23.5	.4	.6	19.1	.4	.4	20.8	2.2	.6	164.5
34	.8	1.2	19.5	.5	1.2	22.7	.7	1.9	25.3	.7	.7	20.9	.7	.9	22.0	3.2	.6	181.3
35	.7	1.4	20.6	.4	1.7	15.5	.5	1.2	14.8	.4	.9	13.0	.4	.8	12.6	3.0	1.2	223.4
36	.7	1.4	22.7	.5	1.0	14.9	.4	.9	14.4	.4	.9	12.4	.3	.8	10.6	3.8	.4	204.7
37	2.1	.9	31.9	1.3	.1	18.3	1.0	.3	17.5	1.0	.3	14.4	.9	.2	15.7	3.3	.2	218.9
38	2.1	1.3	29.8	1.4	.9	17.1	1.2	.7	15.1	1.2	.6	14.7	1.1	.8	13.2	10.3	.2	169.0
39	.9	1.6	36.4	.6	1.3	20.6	.5	1.2	15.9	.4	.9	12.1	.4	.8	11.6	9.5	.1	203.2
40	1.7	.8	27.7	1.2	1.1	19.7	1.1	.9	15.2	.8	.5	12.4	.8	.5	10.2	6.6	.3	158.6
41	1.7	1.5	53.6	1.2	.9	36.8	1.2	.8	27.5	1.0	.8	20.0	.8	.8	19.1	1.8	.5	186.7
42	1.3	1.1	43.1	1.0	1.0	27.5	.9	.8	28.2	.7	.6	21.3	.6	.6	18.3	3.7	.4	195.8
44	2.5	1.1	52.9	1.4	1.1	37.3	1.4	.9	30.2	1.2	.8	23.2	.9	.6	23.8	2.2	.2	87.9
45	2.5	1.2	43.1	1.3	1.0	31.5	1.1	.8	24.0	1.1	.7	23.8	1.1	.6	23.2	2.2	.2	71.9

TABLE A-7. NITRATE, AMMONIUM AND CHLORIDE CONTENT OF SOIL AND WATER SAMPLES FROM LOW N CORN RYEGRASS IN 1976

	0-15 cm			15-30 cm			30-46 cm			46-61 cm			61-91 cm			Wells		
Week	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl
	ppm																	
20	2.5	1.4	4.0	1.8	.8	3.2	1.6	.9	2.4	1.5	.9	1.9	1.4	.6	1.9			
24	8.7	1.8	11.4	3.4	2.2	3.7	2.4	1.0	2.9	2.3	1.0	1.4	2.1	.5	2.0	2.5	.7	38.5
25	5.8	2.8	28.5	3.3	1.6	9.8	2.7	1.0	6.1	2.3	.6	4.7	2.5	.6	3.0	6.0	.2	48.0
26	1.8	3.5	37.1	1.0	2.9	12.6	.9	1.1	8.4	.8	.7	6.1	.8	.8	6.1	4.0	.2	150.2
27	2.5	2.0	32.9	1.3	2.0	18.3	1.1	1.3	14.2	1.0	1.0	11.7	.9	.7	25.1	3.7	.6	102.1
28	1.9	1.7	40.8	.9	1.1	19.4	.9	1.1	13.8	.9	1.4	10.7	1.6	1.0	8.5	3.1	.8	121.6
29	2.1	2.0	52.5	1.4	1.3	23.3	1.1	1.2	16.2	1.2	1.0	15.0	1.2	.9	14.4	2.9	.7	153.8
30	1.8	1.6	62.2	.9	1.3	33.6	.8	.9	20.5	.8	.8	16.6	.6	.6	12.9	2.7	.3	125.2
31	1.5	1.3	67.7	.7	.9	24.6	.9	.6	16.4	.8	.6	13.4	.8	.4	10.7	2.2	.4	135.2
32	1.1	2.1	36.8	.7	1.7	33.6	.7	1.3	32.0	.6	1.1	26.8	.6	1.1	23.9	2.2	.6	164.2
33	.8	1.5	30.7	.5	1.0	24.1	.5	.6	23.5	.4	.6	19.1	.4	.4	20.8	2.2	.6	164.5
34	.8	1.2	19.5	.5	1.2	22.7	.7	1.9	25.3	.7	.7	20.9	.7	.9	22.0	3.2	.6	181.3
35	.7	1.4	20.6	.4	1.7	15.5	.5	1.2	14.8	.4	.9	13.0	.4	.8	12.6	3.0	1.2	223.4
36	.7	1.4	22.7	.5	1.0	14.9	.4	.9	14.4	.4	.9	12.4	.3	.8	10.6	3.8	.4	204.7
37	2.1	.9	31.9	1.3	.1	18.3	1.0	.3	17.5	1.0	.3	14.4	.9	.2	15.7	3.3	.2	218.9
38	2.1	1.3	29.8	1.4	.9	17.1	1.2	.7	15.1	1.2	.6	14.7	1.1	.8	13.2	10.3	.2	169.0
39	.9	1.6	36.4	.6	1.3	20.6	.5	1.2	15.9	.4	.9	12.1	.4	.8	11.6	9.5	.1	203.2
40	1.7	.8	27.7	1.2	1.1	19.7	1.1	.9	15.2	.8	.5	12.4	.8	.5	10.2	6.6	.3	158.6
41	1.7	1.5	53.6	1.2	.9	36.8	1.2	.8	27.5	1.0	.8	20.0	.8	.8	19.1	1.8	.5	186.7
42	1.3	1.1	43.1	1.0	1.0	27.5	.9	.8	28.2	.7	.6	21.3	.6	.6	18.3	3.7	.4	195.8
44	2.5	1.1	52.9	1.4	1.1	37.3	1.4	.9	30.2	1.2	.8	23.2	.9	.6	23.8	2.2	.2	87.9
45	2.5	1.2	43.1	1.3	1.0	31.5	1.1	.8	24.0	1.1	.7	23.8	1.1	.6	23.2	2.2	.2	71.9

TABLE A-8. NITRATE, AMMONIUM AND CHLORIDE CONTENT OF SOIL AND WELL SAMPLES FROM LOW N RYEGRASS IN 1976

	0-15 cm			15-30 cm			30-46 cm			46-61 cm			61-91 cm			Wells		
Week	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl	NO_3-N	NH_4-N	Cl
	ppm																	
20	2.2	1.6	3.7	1.6	1.1	2.4	1.5	1.3	2.1	1.5	.7	2.1	1.6	.6	1.9			
24	11.1	2.3	9.9	5.0	2.2	4.4	2.9	1.1	1.9	2.3	.9	1.4	2.3	.6	1.6	11.2	1.1	71.1
25	10.9	2.5	26.8	5.8	1.6	10.1	4.6	.7	4.6	3.5	.4	3.5	3.0	.4	2.5	9.8	.1	29.7
26	5.1	3.1	40.0	2.8	2.0	13.8	2.1	1.2	9.3	1.4	1.0	5.5	1.1	.4	3.3	8.3	.1	69.3
27	4.9	2.1	36.2	3.3	1.7	15.8	2.6	1.4	8.9	1.9	1.1	7.6	1.4	.7	5.9	9.3	1.1	77.3
28	3.2	1.5	40.4	2.3	1.4	14.7	1.8	1.1	12.2	1.5	.9	10.0	1.1	.8	6.6	7.5	1.0	102.5
29	3.3	1.3	50.3	1.8	1.7	23.1	1.9	1.3	15.4	1.5	.7	10.2	1.4	.9	7.6	6.9	1.0	114.1
30	2.3	1.3	66.7	1.4	2.2	29.9	1.5	1.3	20.2	1.3	1.1	15.4	1.1	.9	13.5	10.2	.4	132.7
31	2.0	1.3	78.9	1.0	1.2	27.9	.9	.8	18.3	1.0	.6	20.8	1.1	.5	12.0	9.5	.5	127.4
32	1.6	2.1	39.2	.9	1.4	30.0	.8	1.0	24.2	.9	1.0	22.7	.9	1.0	20.7	.9	1.5	218.6
33	1.5	1.9	30.0	.9	1.2	24.1	.8	1.8	17.3	.6	.6	16.7	.7	.5	16.2	8.0	.7	218.6
34	1.0	1.7	20.1	.7	1.0	19.0	.7	.8	16.7	.6	.6	15.9	.7	.5	17.4	5.0	1.2	214.5
35	.6	1.2	20.6	.6	.9	13.6	.5	.7	14.6	.5	.8	11.7	.5	.8	12.0	4.3	1.0	232.4
36	.9	1.4	26.1	.5	1.2	13.7	.5	.8	11.4	.4	.8	8.9	.5	.9	9.1	4.6	.5	199.8
37	2.4	.5	32.4	1.6	.2	18.8	1.4	.1	16.0	1.3	.1	16.2	1.0	.1	13.7	4.5	.2	231.8
38	2.2	.8	32.4	1.5	1.0	18.9	1.5	1.1	14.3	1.1	.9	11.3	1.1	1.0	11.2	6.1	.1	159.3
39	1.1	1.7	36.4	.6	1.3	19.6	.5	1.2	12.9	.5	1.0	12.7	.5	.7	11.6	3.0	.1	200.0
40	1.8	.7	27.7	1.1	.7	14.8	.9	.7	11.8	.9	.5	11.7	.9	.4	10.6	8.6	.4	161.4
41	1.6	1.0	49.2	1.2	1.0	27.8	1.1	.8	22.4	.9	1.0	17.3	.9	.8	16.2	4.9	.4	202.4
42	1.5	.9	39.9	1.1	1.5	27.8	1.2	1.2	21.1	1.0	.9	19.3	.8	.5	14.4	3.3	.3	138.6
44	3.0	1.2	97.3	2.0	.8	55.8	1.3	.8	27.2	1.0	.7	19.9	1.1	.5	18.1	2.0	.2	82.4
45	3.3	1.3	88.6	1.6	.8	38.7	1.8	1.3	21.7	1.4	1.0	17.5	1.3	.7	17.2	1.5	.3	59.9

TABLE A-9. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM LOW N CORN IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm				ppm		
19	6.9 (1.9)*	3.7 (0.6)	1028 (187)	6.1 (0.3)	2.1 (0.8)	1.7 (1.2)	5.6 (0.4)
20	8.2 (0.9)	3.7 (3.2)			2.2 (0.6)	3.2 (4.0)	
21	5.6 (0.4)	0.2 (0.2)			2.5 (0.5)	0.5 (0.5)	
22	5.1 (0.4)	0.5 (0.1)			2.9 (0.3)	0.6 (0.2)	
23	9.2 (1.6)	0.9 (0.3)			4.4 (0.6)	0.6 (0.2)	
24	6.6 (1.2)	0.6 (0.4)			4.3 (0.5)	1.1 (0.6)	
25	7.2 (0.8)	1.8 (0.5)			3.9 (0.4)	1.4 (0.3)	
26	6.8 (0.9)	1.2 (0.4)			3.2 (0.5)	1.2 (0.3)	
27	13.0 (0.8)	1.1 (0.3)			4.0 (0.4)	1.9 (0.4)	
28	9.0 (1.0)	1.6 (0.1)			3.8 (0.2)	1.2 (0.3)	
29	5.8 (1.1)	4.9 (4.2)			1.8 (0.7)	2.7 (1.1)	
30	4.0 (1.2)	1.5 (0.3)			2.3 (0.4)	1.7 (0.6)	
31	5.1 (1.1)	1.0 (0.1)			1.4 (0.3)	1.4 (0.7)	
32	2.5 (0.8)	1.4 (0.7)			1.5 (0.3)	1.0 (0.4)	
33	1.8 (0.9)	1.6 (0.6)			0.7 (0.1)	1.5 (0.2)	
34	2.4 (1.2)	1.2 (0.4)			1.5 (1.1)	1.1 (0.5)	
35	3.3 (1.7)	0.8 (0.3)			0.7 (0.3)	0.7 (0.2)	
36	2.6 (0.8)	0.8 (0.2)			1.1 (0.5)	1.1 (0.6)	
37	1.9 (0.4)	0.9 (0.4)			0.4 (0.2)	0.8 (0.3)	
38	1.2 (0.9)	1.3 (0.7)			0.5 (0.2)	1.2 (0.3)	
39	2.6 (0.8)	0.9 (0.5)			1.7 (0.7)	1.0 (0.3)	
40	1.4 (0.2)	0.5 (0.0)			0.2 (0.1)	1.2 (0.6)	
41	1.4 (0.6)	0.6 (0.7)			0.4 (0.2)	1.2 (1.2)	
42	1.8 (1.1)	1.4 (1.2)			0.3 (0.3)	0.6 (0.4)	
43	1.9 (0.4)	3.9 (6.7)			0.8 (0.4)	0.8 (0.3)	
44	2.0 (0.5)	0.6 (0.4)			1.2 (0.3)	0.5 (0.1)	
45	2.0 (0.2)	0.8 (0.2)			0.7 (0.2)	1.2 (0.4)	
46	2.3 (0.8)	0.8 (0.3)			0.4 (0.2)	0.4 (0.3)	
47	2.0 (0.7)	3.1 (1.1)	986 (461)	6.4 (0.3)	0.8 (0.5)	2.3 (2.2)	5.6 (0.3)

*Standard Deviation

TABLE A-10. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM LOW N CORN IN RYE IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	---ppm---				---ppm---		
19	5.8 (1.2)*	3.6 (1.7)	1096 (290)	6.1 (0.3)	1.4 (0.4)	2.7 (1.0)	5.7 (0.2)
20	7.3 (1.5)	1.8 (0.5)			1.8 (0.6)	1.2 (0.1)	
21	5.7 (1.5)	0.2 (0.3)			2.0 (0.9)	0.1 (0.1)	
22	4.4 (0.5)	0.5 (0.1)			2.1 (0.8)	0.7 (0.2)	
23	7.0 (2.7)	1.1 (0.6)			2.6 (0.8)	0.9 (0.3)	
24	4.5 (0.6)	1.1 (0.5)			2.8 (1.2)	3.0 (3.2)	
25	6.6 (0.7)	1.3 (0.4)			2.6 (0.3)	1.5 (0.4)	
26	4.5 (0.9)	1.4 (0.6)			1.2 (0.2)	1.1 (0.4)	
27	10.8 (1.7)	1.3 (0.5)			2.7 (0.3)	1.5 (0.4)	
28	10.5 (2.1)	4.0 (3.2)			3.3 (0.5)	1.4 (0.4)	
29	7.8 (2.9)	4.0 (4.4)			1.4 (0.4)	2.0 (0.3)	
30	5.2 (1.2)	1.5 (0.2)			1.5 (0.4)	1.6 (0.7)	
31	6.0 (2.2)	1.8 (0.7)			1.0 (0.3)	1.4 (0.2)	
32	3.6 (1.3)	1.0 (0.2)			1.6 (0.2)	1.6 (0.3)	
33	3.0 (0.4)	1.6 (1.1)			0.7 (0.2)	1.6 (0.7)	
34	4.7 (2.8)	1.4 (0.3)			1.6 (0.8)	1.7 (1.0)	
35	4.1 (1.5)	1.3 (0.8)			0.7 (0.3)	0.8 (0.5)	
36	4.1 (1.2)	1.8 (1.1)			1.0 (0.2)	1.2 (1.3)	
37	2.8 (1.6)	1.2 (0.3)			0.4 (0.3)	1.2 (0.2)	
38	1.8 (0.7)	2.3 (1.0)			0.3 (0.2)	1.2 (0.2)	
39	4.2 (1.3)	2.1 (1.3)			1.8 (0.8)	1.0 (0.4)	
40	2.7 (0.8)	1.4 (1.1)			0.7 (0.8)	0.8 (0.2)	
41	2.0 (0.8)	1.6 (1.2)			0.6 (0.4)	0.6 (0.1)	
42	3.1 (0.9)	0.8 (0.5)			0.5 (0.2)	0.8 (0.6)	
43	3.6 (1.6)	0.4 (0.1)			1.2 (0.3)	0.8 (0.4)	
44	4.0 (1.0)	0.7 (0.4)			1.4 (0.4)	0.6 (0.3)	
45	2.9 (0.6)	0.8 (0.3)			1.0 (0.7)	0.7 (0.3)	
46	1.7 (0.7)	2.0 (0.7)			0.3 (0.1)	0.8 (0.4)	
47	2.1 (0.6)	4.0 (1.2)	795 (230)	6.8 (0.5)	1.1 (0.4)	3.1 (0.8)	6.6 (0.4)

*Standard Deviation

TABLE A-11. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM LOW N CORN IN RYEGRASS IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm	ppm	ppm		ppm	ppm	
19	4.5 (2.1)*	4.6 (1.7)	1096 (195)	6.3 (0.1)	1.1 (0.1)	3.1 (0.8)	6.2 (0.2)
20	4.3 (1.6)	1.4 (0.5)			1.7 (1.2)	1.7 (0.4)	
21	4.7 (2.5)	0.2 (0.2)			0.9 (0.2)	0.1 (0.1)	
22	3.2 (0.6)	0.5 (0.3)			1.4 (0.4)	0.5 (0.2)	
23	4.9 (0.4)	0.8 (0.2)			2.2 (0.4)	0.6 (0.2)	
24	3.3 (0.8)	1.2 (0.5)			1.9 (0.4)	0.7 (0.2)	
25	5.6 (1.8)	2.2 (1.0)			2.2 (0.6)	1.6 (0.3)	
26	4.2 (1.8)	1.8 (0.5)			1.0 (0.4)	1.7 (0.4)	
27	10.2 (2.8)	2.2 (0.9)			2.4 (0.4)	1.5 (0.2)	
28	8.8 (2.8)	2.6 (1.9)			3.0 (0.9)	1.6 (0.4)	
29	8.2 (2.4)	6.0 (5.3)			1.4 (0.6)	3.2 (1.2)	
30	4.4 (2.1)	2.6 (0.5)			1.8 (0.6)	2.0 (0.8)	
31	5.6 (2.1)	4.2 (2.8)			1.6 (1.2)	4.3 (4.2)	
32	3.9 (1.0)	3.2 (2.3)			1.9 (0.5)	1.2 (0.3)	
33	2.5 (1.2)	3.7 (1.4)			1.0 (0.5)	2.2 (1.5)	
34	4.1 (3.4)	3.1 (1.1)			1.1 (0.7)	1.7 (0.8)	
35	4.9 (1.3)	1.8 (0.9)			1.3 (1.1)	1.0 (0.1)	
36	3.3 (1.8)	2.2 (1.2)			1.1 (1.1)	1.2 (0.4)	
37	1.6 (1.2)	2.2 (0.9)			0.4 (0.2)	1.3 (0.1)	
38	1.0 (0.8)	2.0 (1.0)			0.2 (0.2)	1.4 (0.6)	
39	2.3 (1.1)	2.5 (2.7)			1.3 (0.2)	0.9 (0.2)	
40	1.5 (1.1)	0.9 (0.5)			0.2 (0.2)	0.9 (0.4)	
41	1.5 (1.4)	3.4 (1.1)			0.3 (0.2)	0.7 (0.5)	
42	1.6 (1.9)	1.2 (1.0)			0.2 (0.3)	1.3 (0.9)	
43	2.0 (1.2)	1.2 (1.1)			0.9 (0.2)	0.7 (0.2)	
44	2.2 (0.7)	1.1 (0.7)			1.0 (0.2)	0.9 (0.3)	
45	1.5 (0.6)	1.7 (0.8)			0.5 (0.2)	0.9 (0.4)	
46	2.9 (0.8)	1.2 (0.5)			0.2 (0.1)	1.5 (1.0)	
47	1.7 (0.8)	3.8 (1.6)		6.5 (0.5)	0.5 (0.3)	4.2 (4.2)	6.2 (0.6)

*Standard Deviation

TABLE A-12. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM LOW N RYEGRASS HAY IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm				ppm		
19	4.4 (2.3)*	3.7 (0.9)	986 (141)	6.6 (0.4)	1.1 (0.4)	4.0 (2.2)	6.2 (0.3)
20	3.8 (1.7)	3.8 (3.0)			0.9 (0.7)	1.8 (0.6)	
21	3.1 (2.5)	0.2 (0.3)			0.8 (0.9)	0.2 (0.2)	
22	2.4 (1.0)	0.9 (1.0)			1.1 (1.0)	0.6 (0.4)	
23	5.0 (1.7)	1.9 (1.9)			1.7 (0.5)	0.8 (0.1)	
24	2.0 (0.7)	1.0 (0.4)			1.1 (0.6)	0.7 (0.3)	
25	3.1 (0.5)	2.2 (0.8)			1.5 (0.3)	1.5 (0.7)	
26	3.0 (1.1)	1.9 (0.9)			1.0 (0.2)	1.1 (0.6)	
27	11.2 (4.3)	1.6 (0.6)			2.9 (1.3)	1.4 (0.6)	
28	7.0 (1.9)	2.0 (0.6)			2.2 (0.5)	2.4 (1.2)	
29	5.3 (4.2)	6.6 (7.2)			1.7 (0.7)	2.4 (1.1)	
30	2.7 (0.5)	3.2 (1.1)			1.4 (0.2)	1.9 (0.3)	
31	7.2 (2.6)	1.6 (0.4)			1.5 (0.9)	1.8 (0.7)	
32	3.4 (1.4)	2.6 (1.5)			1.8 (0.4)	1.2 (0.2)	
33	1.6 (0.5)	2.7 (0.7)			0.8 (0.1)	1.5 (0.2)	
34	3.9 (0.7)	1.5 (0.2)			0.6 (0.2)	0.9 (0.4)	
35	2.8 (2.2)	1.4 (0.2)			0.5 (0.2)	0.8 (0.3)	
36	1.9 (0.7)	1.7 (0.7)			0.9 (0.1)	1.0 (0.3)	
37	0.5 (0.2)	1.3 (0.8)			0.2 (0.2)	0.8 (0.4)	
38	0.7 (0.5)	1.8 (0.5)			0.1 (0.1)	1.3 (0.4)	
39	1.1 (0.3)	2.3 (2.6)			0.9 (0.1)	1.0 (0.9)	
40	0.3 (0.4)	1.5 (1.2)			0.1 (0.1)	1.0 (0.2)	
41	0.3 (0.2)	0.6 (0.5)			0.1 (0.0)	0.4 (0.3)	
42	0.4 (0.5)	1.2 (0.4)			0.1 (0.1)	1.2 (0.6)	
43	1.7 (1.0)	1.2 (0.7)			0.6 (0.1)	0.5 (0.4)	
44	0.7 (0.3)	1.1 (0.5)			0.6 (0.3)	0.7 (0.3)	
45	0.7 (0.4)	1.0 (0.8)			0.4 (0.1)	0.7 (0.1)	
46	2.6 (1.6)	1.5 (0.7)			0.2 (0.2)	0.9 (0.3)	
47	0.9 (0.4)	3.7 (0.7)	603 (173)	7.0 (0.2)	0.3 (0.1)	2.3 (1.1)	6.7 (0.3)

*Standard Deviation

TABLE A-13. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM HIGH N CORN IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm	ppm	ppm		ppm	ppm	
19	16.1 (3.9)*	4.0 (2.7)	1274 (266)	5.3 (0.2)	3.7 (1.1)	1.8 (0.7)	5.6 (0.4)
20	16.4 (2.7)	3.3 (1.3)			6.0 (1.7)	2.1 (0.8)	
21	12.4 (1.8)	0.8 (0.4)			5.7 (2.0)	0.8 (0.2)	
22	10.9 (3.4)	0.5 (0.1)			6.4 (0.9)	0.7 (0.3)	
23	14.6 (2.8)	0.4 (0.2)			9.2 (2.3)	0.7 (0.1)	
24	12.7 (3.6)	0.8 (0.3)			7.4 (1.4)	0.7 (0.4)	
25	10.7 (0.8)	1.3 (0.4)			4.9 (1.2)	1.5 (0.4)	
26	9.7 (1.8)	1.2 (0.6)			4.1 (0.5)	1.5 (0.7)	
27	16.0 (2.3)	1.4 (0.2)			5.4 (1.3)	1.8 (0.9)	
28	13.9 (3.0)	1.7 (0.5)			6.2 (1.7)	1.8 (0.3)	
29	7.4 (0.4)	1.2 (0.3)			4.6 (1.8)	1.3 (0.6)	
30	6.9 (0.6)	1.1 (0.3)			4.5 (1.3)	1.5 (0.1)	
31	8.1 (2.1)	1.9 (1.7)			4.2 (1.4)	1.1 (0.3)	
32	5.4 (0.9)	1.3 (0.7)			3.8 (0.4)	0.9 (0.6)	
33	3.0 (1.2)	2.2 (1.9)			2.4 (0.6)	2.6 (2.0)	
34	4.9 (2.6)	1.4 (0.5)			2.6 (0.8)	1.1 (0.6)	
35	4.7 (1.8)	0.9 (0.4)			1.2 (0.5)	1.0 (0.4)	
36	3.5 (0.6)	1.0 (0.5)			1.6 (0.3)	1.0 (0.4)	
37	2.4 (0.3)	1.1 (0.2)			0.9 (0.1)	1.0 (0.2)	
38	2.0 (1.2)	0.8 (0.4)			1.9 (1.5)	0.6 (0.2)	
39	3.2 (1.7)	1.0 (0.3)			1.9 (0.6)	1.1 (0.6)	
40	1.9 (0.8)	0.6 (0.3)			1.4 (0.6)	0.7 (0.4)	
41	2.2 (1.0)	0.7 (0.4)			0.8 (0.4)	1.7 (1.0)	
42	1.9 (0.9)	1.5 (1.3)			1.0 (0.4)	1.0 (0.5)	
43	2.4 (0.2)	1.4 (2.0)			1.4 (0.2)	0.2 (0.3)	
44	2.6 (0.8)	0.6 (0.3)			1.7 (1.7)	0.5 (0.4)	
45	3.9 (0.3)	2.5 (3.4)			1.6 (1.6)	0.9 (0.2)	
46	3.2 (1.1)	1.3 (0.1)			1.4 (1.4)	1.3 (0.0)	
47	2.8 (0.7)	4.4 (1.8)	1356 (321)	6.4 (0.6)	1.0 (1.0)	3.7 (0.6)	6.1 (0.8)

*Standard Deviation

TABLE A-14. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM HIGH N CORN IN RYE IN 1977

	0-15 cm				15-30 cm		
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm				ppm		
19	13.5 (3.9)	2.0 (2.3)	1754 (397)	5.6 (0.3)	5.2 (0.9)	2.1 (1.5)	5.8 (0.4)
20	15.6 (4.1)	1.7 (0.9)			5.4 (1.2)	2.2 (0.7)	
21	9.7 (2.1)	0.9 (0.5)			5.0 (1.0)	0.8 (0.4)	
22	7.5 (1.6)	0.6 (0.3)			4.6 (1.1)	0.5 (0.2)	
23	10.4 (2.9)	0.8 (0.1)			5.3 (2.1)	1.0 (0.4)	
24	9.0 (2.9)	0.7 (0.3)			5.1 (1.0)	0.9 (0.3)	
25	7.7 (0.8)	1.3 (0.7)			3.2 (0.2)	1.3 (0.3)	
26	9.1 (3.1)	2.1 (0.9)			3.0 (1.2)	1.6 (1.0)	
27	17.2 (6.1)	1.4 (0.2)			4.7 (0.2)	1.6 (0.9)	
28	14.4 (2.7)	1.6 (0.3)			7.0 (2.1)	2.6 (2.0)	
29	10.8 (2.4)	1.8 (0.8)			5.0 (2.3)	2.0 (1.0)	
30	8.2 (2.1)	1.4 (0.2)			4.9 (1.4)	2.0 (0.5)	
31	7.7 (0.6)	1.7 (0.7)			3.5 (2.0)	1.5 (0.6)	
32	6.8 (1.9)	1.1 (0.5)			3.6 (0.5)	1.2 (0.6)	
33	2.4 (1.8)	3.5 (2.7)			1.5 (0.5)	2.0 (1.2)	
34	6.0 (3.8)	1.1 (0.1)			3.8 (2.9)	1.9 (0.4)	
35	6.2 (1.4)	1.4 (0.4)			1.8 (0.8)	1.9 (1.0)	
36	5.1 (1.7)	1.6 (0.2)			2.3 (1.1)	1.5 (0.6)	
37	2.5 (1.2)	1.1 (0.3)			0.9 (0.5)	1.0 (0.2)	
38	2.4 (1.1)	1.0 (0.2)			1.2 (0.8)	1.0 (0.5)	
39	3.6 (1.7)	0.9 (0.4)			1.7 (0.7)	0.8 (0.7)	
40	3.3 (1.2)	0.7 (0.5)			1.2 (0.6)	1.2 (0.9)	
41	2.8 (1.7)	1.3 (0.2)			0.8 (0.3)	1.3 (0.6)	
42	2.3 (1.2)	1.0 (0.3)			0.8 (0.5)	0.7 (0.2)	
43	3.4 (1.6)	0.6 (0.4)			1.5 (0.6)	0.4 (0.4)	
44	5.2 (1.8)	0.8 (0.3)			2.2 (0.9)	0.8 (0.2)	
45	3.6 (0.1)	1.2 (0.6)			1.7 (0.5)	1.1 (0.4)	
46	4.0 (1.0)	1.7 (0.7)			2.4 (0.9)	1.3 (0.8)	
47	4.1 (1.2)	5.2 (4.3)	1534 (458)	6.4 (0.3)	1.8 (0.9)	3.3 (2.3)	6.5 (0.4)

*Standard Deviation

TABLE A-15. NITRATE, AMMONIUM, KJELDAHL N, AND pH OF SOIL SAMPLES FROM HIGH N RYEGRASS HAY IN 1977

Week	0-15 cm				15-30 cm		
	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	pH
	ppm	ppm	ppm		ppm	ppm	
19	16.2 (3.8)*	3.3 (1.3)	1717 (541)	5.7 (0.6)	6.0 (2.7)	3.2 (0.8)	6.1 (0.4)
20	15.6 (2.4)	3.5 (1.0)			5.9 (2.6)	3.4 (3.0)	
21	12.9 (6.1)	0.9 (0.2)			4.9 (3.2)	0.8 (0.3)	
22	5.2 (1.9)	0.4 (0.3)			3.6 (1.4)	0.4 (0.1)	
23	9.0 (3.3)	1.2 (1.2)			4.6 (1.8)	0.7 (0.1)	
24	7.3 (1.2)	1.1 (0.6)			4.6 (1.8)	1.5 (1.4)	
25	6.7 (0.9)	1.0 (0.3)			3.4 (1.1)	1.0 (0.3)	
26	5.5 (0.6)	1.5 (0.7)			2.1 (0.4)	1.2 (0.4)	
27	11.2 (3.5)	1.4 (0.6)			3.3 (1.0)	1.9 (0.6)	
28	9.0 (0.9)	2.2 (0.6)			3.4 (0.7)	1.2 (1.2)	
29	6.5 (2.2)	3.0 (1.6)			1.8 (0.8)	1.4 (0.6)	
30	4.6 (1.0)	4.0 (2.4)			3.2 (0.3)	1.8 (0.4)	
31	9.0 (3.4)	2.6 (1.5)			2.2 (0.6)	1.9 (0.8)	
32	5.8 (2.1)	2.2 (1.0)			3.0 (0.6)	1.5 (0.6)	
33	2.0 (1.4)	5.6 (2.2)			1.7 (0.5)	2.7 (0.9)	
34	5.3 (4.9)	5.1 (2.8)			2.1 (1.0)	1.8 (0.7)	
35	3.7 (1.9)	2.3 (1.5)			0.9 (0.7)	1.0 (0.3)	
36	4.5 (3.0)	4.4 (3.4)			1.4 (1.0)	1.8 (0.8)	
37	1.1 (1.0)	1.4 (0.1)			0.4 (0.3)	1.0 (0.2)	
38	2.8 (0.9)	1.1 (0.7)			0.9 (0.5)	0.7 (0.2)	
39	2.4 (1.0)	1.1 (0.4)			1.6 (0.5)	0.8 (0.2)	
40	1.6 (1.9)	1.8 (1.5)			0.7 (0.6)	0.7 (0.7)	
41	2.2 (1.4)	2.4 (2.4)			0.7 (0.4)	1.1 (0.2)	
42	2.6 (1.4)	1.6 (0.8)			1.0 (0.8)	1.3 (0.6)	
43	2.1 (1.5)	4.1 (5.3)			1.1 (0.1)	0.7 (0.3)	
44	1.9 (0.6)	0.8 (0.5)			1.2 (0.3)	0.9 (0.4)	
45	1.7 (2.2)	1.8 (0.7)			1.3 (1.0)	1.1 (0.6)	
46	2.4 (1.6)	1.5 (0.7)			1.1 (0.7)	2.3 (1.6)	
47	2.5 (2.1)	6.9 (2.9)	1247 (137)	6.4 (0.2)	1.0 (1.0)	3.5 (0.8)	6.4 (0.3)

*Standard Deviation

TABLE A-16. PARAMETERS MONITORED IN SOIL SAMPLES FROM 7 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Spec. Cond.	pH
	ppm				umhos/cm	
19	21.8 (4.1)*	2.8 (2.6)	1452 (182)	7.5 (1.8)	1851 (150)	5.3 (0.3)
20	13.5 (3.4)			33.0 (10.4)		
21	15.0 (3.6)			77.4 (12.0)		
22	15.1 (3.1)			123.9 (97.0)		
23	17.9 (2.8)	1.4 (1.2)	1377 (47)	121.9 (27.6)	2519 (165)	5.8 (0.3)
24	13.2 (1.7)			55.3 (11.6)		
25	12.7 (1.6)			78.5 (4.8)		
26	11.0 (1.5)			44.8 (22.1)		
27	14.0 (5.6)			35.1 (8.4)		
28	14.2 (2.7)	1.3 (0.2)	1261 (232)	36.9 (4.9)	2336 (408)	6.0 (0.3)
29	8.9 (1.8)			55.5 (5.3)		
30	7.9 (1.2)			44.7 (4.0)		
31	8.3 (1.8)			38.0 (3.1)		
32	7.2 (1.1)			20.6 (6.3)		
33	2.9 (2.1)	2.5 (1.7)	1562 (458)	50.6 (11.7)	1019 (72)	6.3 (0.4)
34	5.3 (2.7)			36.2 (7.9)		
35	3.4 (0.5)			18.4 (1.0)		
36	4.7 (1.9)			29.7 (4.0)		
37	2.9 (0.6)			35.5 (8.7)		
38	2.3 (0.4)	0.7 (0.3)	1302 (52)	31.6 (12.6)	1210 (262)	6.5 (0.4)
39	3.1 (0.6)			9.2 (5.7)		
40	2.4 (0.6)			5.1 (2.7)		
41	2.8 (0.8)			2.0 (0.8)		
42	1.8 (0.5)			2.0 (1.4)		
43	2.6 (0.6)	0.4 (0.3)	1343 (221)	4.5 (2.4)	793 (107)	6.8 (0.3)
44	3.2 (0.5)			15.9 (4.0)		
45	3.1 (0.6)			23.2 (0.3)		
46	3.5 (0.8)			14.3 (1.4)		
47	2.3 (1.1)	5.4 (2.0)	1124 (336)	14.6 (4.1)	763 (138)	6.7 (0.3)

*Standard Deviation

(Continued)

TABLE A-16. (Continued)

Week	15-30 cm					
	NO_3-N	NH_4-N	Kjeldahl N	Cl	Spec. Cond.	pH
	ppm	ppm	ppm	ppm	umhos/cm	
19	4.6 (0.9)*	2.1 (1.4)	768 (141)	3.5 (1.8)	904 (50)	5.7 (0.3)
20	6.1 (2.9)			6.9 (2.0)		
21	6.4 (1.9)			32.8 (8.0)		
22	9.8 (1.4)			41.0 (10.2)		
23	10.2 (1.0)	0.9 (0.3)	548 (116)	68.2 (8.7)	1424 (182)	5.5 (0.3)
24	10.5 (1.5)			40.2 (15.0)		
25	7.2 (1.4)			55.3 (12.5)		
26	6.0 (0.6)			20.8 (3.4)		
27	5.7 (0.9)			36.1 (6.0)		
28	6.7 (2.9)	0.8 (0.6)	671 (158)	25.6 (3.2)	1456 (162)	5.5 (0.2)
29	5.2 (2.4)			56.4 (6.3)		
30	4.9 (2.1)			28.1 (5.2)		
31	3.4 (0.3)			34.2 (4.6)		
32	4.9 (0.8)			29.3 (5.6)		
33	2.5 (1.2)	1.4 (0.5)	1000 (432)	28.1 (7.0)	957 (111)	5.6 (0.4)
34	3.5 (0.5)			29.8 (3.0)		
35	1.2 (0.7)			20.0 (3.8)		
36	1.6 (0.9)			23.4 (5.8)		
37	1.1 (0.5)			27.6 (6.6)		
38	1.9 (0.8)	0.9 (0.1)	493 (261)	57.2 (25.0)	1231 (256)	5.8 (0.4)
39	2.4 (1.0)			15.3 (4.9)		
40	1.8 (0.8)			17.6 (8.6)		
41	1.7 (1.5)			6.4 (3.5)		
42	1.3 (0.7)			3.3 (1.6)		
43	1.7 (0.4)	0.8 (0.3)	918 (254)	6.9 (2.1)	824 (70)	6.4 (0.5)
44	1.6 (0.2)			7.4 (2.5)		
45	1.5 (0.3)			12.5 (1.3)		
46	1.7 (0.1)			15.6 (2.0)		
47	1.2 (0.7)	3.2 (1.4)	740 (370)	15.2 (5.9)	601 (92)	6.5 (0.4)

*Standard Deviation

TABLE A-17. PARAMETERS MONITORED IN SOIL SAMPLES FROM 22 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1977

Week	0-15 cm					
	NO_3-N	NH_4-N	Kjeldahl N	Cl	Spec. Cond.	pH
	ppm	ppm	ppm	ppm	umhos/cm	
19	30.2 (6.1)*	10.9 (5.3)	1452 (182)	18.5 (12.2)	2478 (216)	5.5 (0.3)
20	21.4 (7.9)			49.5 (6.5)		
21	22.6 (8.5)			97.0 (19.6)		
22	18.1 (5.8)			72.7 (14.1)		
23	20.5 (5.7)	0.6 (0.1)	1363 (593)	140.4 (36.2)	3056 (160)	5.9 (0.6)
24	13.9 (3.2)			64.4 (19.6)		
25	13.8 (3.6)			78.9 (9.4)		
26	12.5 (2.5)			56.9 (17.4)		
27	13.5 (4.6)			34.9 (9.0)		
28	13.2 (3.8)	1.6 (0.3)	1055 (158)	32.1 (6.5)	2224 (638)	6.1 (0.5)
29	9.0 (1.0)			55.7 (13.4)		
30	8.0 (1.5)			40.5 (5.6)		
31	8.4 (1.3)			31.6 (8.0)		
32	6.5 (2.0)			22.3 (5.7)		
33	4.2 (1.8)	2.6 (3.0)	1452 (365)	41.0 (5.8)	1131 (170)	6.0 (0.4)
34	7.8 (2.1)			35.9 (3.4)		
35	4.9 (1.9)			16.3 (3.7)		
36	6.2 (2.8)			24.0 (1.5)		
37	3.1 (0.8)			26.8 (6.8)		
38	3.7 (1.2)	1.4 (0.8)	1384 (207)	30.7 (2.7)	1346 (278)	6.6 (0.3)
39	3.6 (0.7)			7.8 (1.4)		
40	2.4 (0.8)			3.9 (1.6)		
41	2.2 (0.4)			2.3 (0.5)		
42	2.5 (0.8)			3.9 (1.7)		
43	3.2 (0.9)	0.3 (0.2)	1260 (307)	7.6 (3.7)	860 (122)	7.6 (3.7)
44	3.6 (1.0)			16.8 (2.4)		
45	3.8 (0.8)			23.9 (2.2)		
46	4.0 (1.0)			13.2 (2.6)		
47	2.5 (0.5)	3.5 (1.2)	1192 (315)	11.8 (6.2)	891 (292)	6.3 (0.4)

*Standard Deviation

(Continued)

TABLE A-17. (Continued)

Week	15-30 cm NO_3-N	 NH_4-N	 Kjeldahl N	 Cl	 Spec. Cond.	 pH
	-----------	-----------	ppm	-----------	umhos/cm	
19	5.5 (0.3)*	2.5 (0.5)	685 (243)	2.7 (0.6)	926 (109)	5.7 (0.5)
20	5.4 (2.0)			10.6 (2.2)		
21	11.6 (1.6)			40.0 (5.9)		
22	12.3 (1.8)			48.4 (3.1)		
23	15.4 (3.7)	1.0 (0.3)	658 (418)	68.5 (19.5)	1926 (339)	5.4 (0.5)
24	11.5 (2.1)			36.7 (16.0)		
25	8.4 (2.2)			52.3 (12.7)		
26	7.4 (0.2)			24.9 (5.8)		
27	6.0 (1.4)			32.1 (6.4)		
28	7.6 (3.4)	2.6 (1.1)	891 (656)	26.1 (2.8)	1784 (298)	5.3 (0.6)
29	6.3 (2.9)			50.6 (5.3)		
30	5.5 (2.0)			32.4 (2.6)		
31	4.2 (1.9)			29.5 (6.7)		
32	5.5 (2.0)			24.8 (5.6)		
33	4.5 (1.3)	2.0 (0.5)	863 (230)	36.3 (8.0)	1112 (110)	5.6 (0.8)
34	4.1 (1.9)			29.8 (2.7)		
35	2.6 (2.8)			17.7 (5.6)		
36	2.4 (1.2)			25.5 (4.3)		
37	1.8 (0.6)			29.2 (4.6)		
38	2.2 (0.9)	1.5 (0.8)	630 (145)	46.9 (9.3)	1462 (256)	5.7 (0.5)
39	2.6 (1.1)			16.3 (6.6)		
40	1.3 (0.1)			9.2 (4.0)		
41	1.2 (0.1)			4.7 (2.6)		
42	1.4 (0.5)			4.6 (1.8)		
43	1.8 (0.5)	0.1 (0.2)	794 (292)	7.5 (2.3)	915 (81)	7.5 (2.3)
44	2.1 (0.5)			8.3 (1.9)		
45	1.9 (0.2)			15.0 (2.6)		
46	2.0 (0.9)			14.3 (2.1)		
47	1.6 (0.7)	3.7 (1.9)	726 (181)	12.2 (6.1)	648 (129)	6.2 (0.5)

*Standard Deviation

TABLE A-18. PARAMETERS MONITORED IN SOIL SAMPLES FROM LOW N CORN IN 1978

Week	0-15 cm				15-30 cm			
	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	----------ppm----------				----------ppm----------			
15	1.4 (0.3)*	4.0 (0.4)	872 (261)	6.4 (0.2)	0.5 (0.1)	3.2 (1.0)	645 (208)	5.9 (0.4)
18	3.8 (0.3)	3.6 (1.3)			1.6 (0.4)	3.0 (0.4)		
20	4.0 (0.9)	2.7 (1.1)			2.1 (0.4)	1.6 (0.5)		
21	8.1 (1.6)	2.1 (1.2)			4.4 (1.0)	2.2 (1.0)		
22	7.0 (1.6)	3.9 (0.6)			3.2 (0.2)	3.2 (0.2)		
23	9.3 (1.7)	4.5 (2.6)			3.2 (0.5)	3.6 (0.8)		
24	7.5 (1.4)	5.7 (1.8)			3.3 (0.5)	3.8 (1.0)		
25	4.0 (0.3)	4.9 (1.6)			3.4 (1.2)	4.5 (1.2)		
26	2.5 (0.6)	3.5 (1.1)			1.8 (0.4)	3.1 (1.5)		
27	2.4 (0.8)	7.6 (4.5)			0.7 (0.2)	4.5 (1.1)		
28	2.9 (0.6)	2.5 (0.2)			1.0 (0.2)	2.6 (0.4)		
29	3.2 (0.6)	2.8 (0.9)			1.2 (0.4)	2.3 (1.2)		
30	5.3 (3.6)	5.1 (2.0)			1.1 (0.6)	4.2 (1.1)		
31	3.6 (1.1)	5.7 (1.4)			0.8 (0.2)	4.0 (0.9)		
32	4.7 (3.0)	5.1 (1.8)			1.2 (0.4)	4.0 (1.0)		
33	2.7 (1.6)	4.6 (0.8)			1.0 (0.4)	2.5 (0.7)		
34	2.5 (0.7)	4.5 (1.3)			1.0 (0.2)	5.5 (2.5)		
35	2.9 (1.8)	5.5 (1.5)			1.8 (1.0)	2.0 (0.6)		
36	2.2 (0.3)	8.9 (3.4)			1.0 (0.2)	4.6 (2.9)		
37	3.3 (0.9)	7.1 (3.3)			1.0 (0.2)	3.6 (0.8)		
38	3.7 (0.9)	4.4 (2.3)			1.4 (0.1)	3.2 (0.9)		
39	2.9 (0.6)	3.9 (1.7)			1.4 (0.6)	3.2 (1.2)		
40	2.6 (0.6)	4.4 (0.7)			1.5 (0.4)	2.5 (0.5)		
41	3.5 (1.9)	2.7 (0.1)			2.4 (1.3)	2.7 (0.9)		
42	2.8 (0.9)	4.0 (0.4)			2.0 (0.3)	3.1 (0.6)		
43	2.5 (0.4)	3.2 (1.6)			1.2 (0.5)	3.3 (1.2)		
44	2.1 (0.8)	1.4 (0.7)			1.2 (0.4)	1.6 (0.6)		
45	1.8 (0.2)	2.0 (0.2)			1.2 (0.2)	3.8 (0.8)		
46	2.4 (0.7)	2.2 (0.2)			1.8 (0.3)	2.3 (0.4)		
47	2.9 (0.7)	2.7 (0.9)			1.3 (0.3)	3.3 (0.5)		
48	3.8 (1.1)	1.5 (0.2)	811 (338)	7.0 (0.4)	1.5 (0.4)	1.6 (0.3)		6.3 (0.7)

*Standard Deviation

TABLE A-19. PARAMETERS MONITORED IN SOIL SAMPLES FROM LOW N CORN IN RYE IN 1978

	0-15 cm				15-30 cm			
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	ppm				ppm			
15	1.6 (0.4)*	6.0 (1.3)	758 (309)	6.9 (0.4)	0.5 (0.1)	2.7 (0.2)	321 (144)	6.5 (0.4)
18	4.4 (1.6)	3.2 (0.8)			1.6 (0.9)	3.5 (1.6)		
20	4.3 (1.0)	1.9 (0.5)			1.5 (0.5)	1.9 (1.0)		
21	8.9 (2.2)	1.7 (0.5)			4.0 (1.3)	1.8 (1.5)		
22	7.8 (1.4)	4.5 (1.7)			3.3 (0.6)	2.8 (0.5)		
23	9.6 (0.5)	2.6 (1.4)			2.9 (1.0)	3.9 (2.4)		
24	5.0 (1.7)	5.3 (1.0)			3.0 (0.7)	3.5 (0.7)		
25	4.7 (1.0)	5.8 (1.7)			2.7 (1.3)	3.7 (0.5)		
26	2.6 (0.9)	4.3 (1.5)			1.0 (0.3)	3.2 (2.3)		
27	3.9 (2.2)	6.5 (2.6)			0.7 (0.2)	3.7 (1.1)		
28	2.2 (0.4)	3.1 (1.3)			0.6 (0.0)	3.3 (0.8)		
29	2.6 (1.2)	2.1 (0.6)			1.5 (1.4)	2.5 (0.7)		
30	4.2 (2.3)	6.1 (1.0)			2.6 (3.2)	5.6 (1.8)		
31	3.5 (2.2)	9.7 (2.5)			1.0 (0.4)	7.0 (4.3)		
32	5.5 (1.5)	7.7 (2.9)			0.9 (0.2)	4.5 (0.1)		
33	3.6 (1.6)	7.4 (0.7)			0.7 (0.2)	2.5 (0.7)		
34	3.6 (1.4)	7.6 (1.6)			1.0 (0.1)	4.9 (1.8)		
35	4.3 (1.2)	6.8 (3.7)			1.3 (0.3)	3.0 (0.9)		
36	2.4 (0.9)	11.2 (1.9)			0.8 (0.2)	4.6 (1.5)		
37	2.4 (0.5)	12.8 (2.5)			0.9 (0.1)	4.8 (0.9)		
38	4.5 (1.0)	5.4 (2.1)			1.5 (0.1)	2.8 (0.6)		
39	3.4 (1.2)	6.6 (3.0)			1.3 (0.5)	4.9 (3.1)		
40	3.2 (0.6)	6.3 (0.2)			1.2 (0.2)	2.8 (1.2)		
41	4.7 (1.2)	8.7 (9.7)			1.6 (0.2)	2.2 (0.4)		
42	3.3 (1.0)	5.9 (0.8)			1.8 (0.3)	4.3 (1.0)		
43	3.0 (1.8)	3.6 (1.4)			1.3 (0.4)	3.0 (1.0)		
44	2.4 (0.8)	2.4 (1.1)			1.1 (0.3)	1.9 (0.5)		
45	2.1 (1.0)	2.3 (0.4)			1.5 (0.4)	3.7 (1.0)		
46	2.5 (1.0)	5.2 (3.2)			2.3 (0.9)	2.4 (0.7)		
47	4.2 (2.0)	6.8 (7.1)			1.5 (0.6)	3.7 (1.2)		
48	3.7 (0.9)	2.6 (0.9)	795 (198)	6.9 (0.4)	1.0 (0.2)	1.5 (0.3)		6.5 (0.6)

*Standard Deviation

TABLE A-20. PARAMETERS MONITORED IN SOIL SAMPLES FROM LOW N CORN IN RYEGRASS IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	ppm				ppm			
15	3.2 (0.4)*	7.7 (2.6)	877 (356)	6.6 (0.4)	1.1 (0.5)	3.6 (0.6)	384 (334)	6.3 (0.2)
18	7.6 (1.6)	5.2 (0.7)			2.0 (0.6)	3.8 (1.0)		
20	6.3 (1.8)	2.6 (0.8)			2.6 (0.5)	2.5 (0.4)		
21	11.6 (6.7)	0.9 (1.0)			6.4 (0.8)	1.9 (1.2)		
22	8.2 (1.5)	5.9 (1.5)			3.7 (0.5)	3.0 (0.5)		
23	9.9 (1.9)	6.6 (3.3)			4.0 (0.4)	3.0 (0.3)		
24	7.2 (0.8)	5.9 (1.5)			3.6 (1.1)	3.8 (1.2)		
25	5.5 (1.5)	7.0 (1.5)			3.3 (0.6)	7.7 (5.2)		
26	3.7 (1.2)	4.9 (2.1)			1.2 (0.6)	4.3 (0.3)		
27	3.9 (1.5)	12.1 (7.3)			1.1 (0.5)	5.9 (2.0)		
28	3.0 (1.0)	2.8 (0.5)			1.0 (0.2)	2.1 (1.5)		
29	3.5 (0.9)	3.6 (1.3)			1.1 (0.4)	3.9 (1.1)		
30	4.4 (2.0)	10.3 (4.7)			1.0 (0.4)	4.8 (1.2)		
31	2.5 (1.0)	6.3 (2.0)			0.6 (0.0)	5.3 (2.9)		
32	5.5 (3.6)	8.0 (3.0)			1.1 (0.4)	4.5 (1.6)		
33	5.4 (4.1)	5.3 (3.7)			0.7 (0.1)	3.4 (0.8)		
34	2.3 (0.6)	7.8 (3.7)			1.0 (0.2)	5.3 (1.6)		
35	3.9 (0.5)	7.4 (3.2)			1.2 (0.3)	2.6 (1.2)		
36	2.4 (1.1)	12.5 (8.6)			1.0 (0.5)	4.3 (2.4)		
37	2.8 (1.5)	11.0 (6.2)			0.9 (0.3)	4.2 (2.7)		
38	4.4 (1.7)	9.0 (3.3)			1.3 (0.6)	5.2 (3.4)		
39	2.7 (2.0)	3.4 (1.5)			1.2 (0.5)	3.7 (2.5)		
40	2.8 (1.8)	7.8 (3.6)			1.2 (0.5)	2.8 (0.6)		
41	3.8 (1.8)	2.7 (0.2)			1.9 (0.8)	2.2 (0.2)		
42	2.1 (0.5)	6.9 (4.6)			1.1 (0.3)	3.7 (1.5)		
43	2.1 (1.5)	5.0 (1.1)			1.2 (0.5)	2.9 (0.6)		
44	1.9 (1.2)	2.4 (1.2)			0.8 (0.2)	1.6 (0.6)		
45	1.7 (0.6)	3.0 (1.3)			1.1 (0.3)	2.9 (0.2)		
46	2.0 (1.1)	2.9 (1.2)			2.3 (0.8)	2.5 (0.5)		
47	3.3 (1.5)	3.2 (1.4)			1.1 (0.3)	8.0 (5.8)		
48	3.6 (1.6)	4.4 (4.8)	890 (220)	6.9 (0.4)	1.3 (0.7)	2.0 (0.6)		6.7 (0.4)

*Standard Deviation

TABLE A-21. PARAMETERS MONITORED IN SOIL SAMPLES FROM LOW N RYEGRASS HAY IN 1978

	0-15 cm				15-30 cm			
Week	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	ppm				ppm			
15	3.2 (0.8)*	9.6 (2.5)	742 (566)	7.0 (0.4)	1.3 (0.9)	3.3 (0.8)	450 (306)	6.8 (0.3)
18	7.3 (3.2)	4.9 (4.9)			2.5 (1.5)	3.6 (0.7)		
20	6.4 (2.8)	1.6 (1.0)			2.6 (1.3)	2.5 (1.0)		
21	5.9 (3.4)	1.7 (1.1)			4.3 (2.0)	2.2 (1.8)		
22	3.6 (2.2)	4.9 (2.4)			1.9 (0.8)	3.0 (0.9)		
23	4.4 (2.2)	7.5 (3.7)			1.9 (0.6)	3.3 (1.1)		
24	1.6 (0.6)	5.4 (1.5)			0.9 (0.6)	3.9 (2.2)		
25	3.5 (0.4)	8.7 (1.9)			1.0 (0.4)	4.9 (1.7)		
26	1.6 (1.2)	5.3 (4.2)			0.6 (0.0)	4.1 (1.0)		
27	1.9 (1.1)	12.1 (5.3)			0.6 (0.0)	4.5 (0.8)		
28	1.0 (0.7)	6.0 (6.6)			0.6 (0.0)	2.8 (0.7)		
29	2.0 (1.1)	3.4 (0.8)			0.7 (0.1)	2.5 (0.6)		
30	3.7 (2.0)	14.9 (2.4)			0.6 (0.1)	5.2 (1.9)		
31	1.4 (0.6)	10.4 (5.5)			0.6 (0.1)	3.2 (1.0)		
32	4.1 (2.1)	9.8 (2.6)			1.0 (0.4)	4.4 (1.2)		
33	3.5 (1.2)	6.3 (3.0)			1.0 (0.3)	2.9 (0.9)		
34	2.3 (0.7)	9.4 (1.2)			1.1 (0.1)	5.0 (1.0)		
35	3.1 (1.0)	8.7 (2.0)			1.0 (0.3)	2.5 (0.9)		
36	1.5 (0.3)	14.6 (3.7)			1.0 (0.4)	3.6 (0.9)		
37	1.1 (0.3)	11.7 (3.8)			0.6 (0.1)	3.9 (0.9)		
38	2.1 (1.3)	6.6 (2.1)			0.8 (0.4)	3.5 (1.2)		
39	2.0 (1.4)	4.6 (1.5)			1.0 (0.3)	3.8 (1.5)		
40	1.2 (0.2)	5.8 (0.8)			1.1 (0.8)	4.0 (2.2)		
42	1.5 (0.2)	5.5 (1.0)			1.0 (0.2)	4.8 (2.2)		
43	1.1 (1.0)	2.9 (0.6)			0.6 (0.0)	2.6 (0.6)		
44	0.8 (0.3)	9.6 (13.2)			0.6 (0.1)	1.6 (0.4)		
45	1.2 (0.3)	3.1 (0.6)			0.9 (0.6)	3.4 (1.3)		
46	1.0 (0.5)	2.3 (1.0)			1.0 (0.2)	1.8 (0.3)		
47	2.1 (0.4)	5.8 (4.2)			0.8 (0.2)	3.5 (0.9)		
48	3.5 (2.2)	3.2 (1.7)	1320 (397)	6.8 (0.3)	1.4 (1.1)	4.2 (4.3)		6.4 (0.6)

*Standard Deviation

TABLE A-22. PARAMETERS MONITORED IN SOIL SAMPLES FROM HIGH N CORN IN 1978

Week	0-15 cm NO_3-N	0-15 cm NH_4-N	0-15 cm Kjeldahl N	0-15 cm pH	15-30 cm NO_3-N	15-30 cm NH_4-N	15-30 cm Kjeldahl N	15-30 cm pH
	ppm				ppm			
16	2.8 (0.5)*	1.6 (0.5)	1423 (425)	6.4 (0.4)	1.3 (0.5)	1.5 (0.8)	1066 (245)	6.3 (0.2)
18	8.7 (4.6)	1.3 (1.2)			3.5 (2.6)	0.5 (0.8)		
20	6.5 (1.4)	0.9 (0.6)			3.4 (0.2)	1.5 (0.2)		
21	12.3 (2.4)	1.3 (2.0)			6.2 (1.9)	0.7 (0.8)		
22	10.8 (4.2)	5.9 (3.0)			3.0 (1.0)	3.7 (0.5)		
23	7.8 (1.0)	1.8 (0.2)			3.2 (1.2)	2.0 (0.6)		
24	6.4 (1.0)	4.4 (0.9)			2.7 (0.6)	4.0 (1.4)		
25	5.6 (0.3)	6.1 (1.1)			4.8 (0.8)	4.4 (0.4)		
26	3.8 (0.7)	2.6 (1.2)			2.5 (0.6)	1.2 (0.3)		
27	1.5 (0.9)	8.4 (5.4)			1.0 (0.4)	7.7 (3.7)		
28	2.0 (0.6)	8.1 (4.0)			1.1 (0.2)	8.2 (6.3)		
29	3.1 (1.1)	4.8 (0.7)			1.1 (0.4)	6.1 (1.8)		
30	5.0 (1.1)	3.6 (0.9)			1.8 (0.7)	2.7 (1.2)		
31	1.3 (0.2)	3.3 (0.4)			0.6 (0.1)	3.6 (1.5)		
32	4.1 (1.2)	5.6 (0.6)			1.5 (0.6)	3.8 (1.2)		
33	4.0 (0.7)	3.8 (0.5)			1.2 (0.3)	4.4 (1.4)		
34	2.0 (0.8)	4.0 (3.0)			1.3 (0.5)	3.5 (1.0)		
35	2.6 (1.1)	4.7 (3.1)			1.7 (1.1)	4.2 (1.9)		
36	2.2 (0.7)	5.2 (2.7)			1.1 (0.2)	4.4 (2.8)		
37	2.9 (0.7)	6.2 (2.6)			1.5 (0.6)	4.7 (2.8)		
38	2.1 (1.2)	4.4 (2.3)			1.6 (1.0)	4.7 (1.2)		
39	1.6 (0.5)	6.6 (4.1)			1.9 (2.1)	5.2 (3.5)		
40	2.9 (1.4)	5.3 (3.6)			1.8 (0.2)	3.3 (1.6)		
41	4.5 (1.3)	2.9 (0.8)			2.4 (0.6)	3.6 (1.8)		
42	3.4 (1.2)	3.1 (1.2)			2.0 (0.7)	3.0 (1.1)		
43	2.1 (1.0)	5.6 (2.2)			0.9 (0.6)	5.2 (0.7)		
44	3.0 (1.6)	3.8 (4.5)			1.4 (0.6)	1.7 (0.5)		
45	3.1 (1.1)	2.5 (1.6)			1.6 (0.7)	1.9 (0.2)		
46	3.4 (1.2)	2.1 (0.4)			1.9 (0.7)	2.3 (0.5)		
47	3.9 (2.2)	5.8 (5.6)			2.0 (1.1)	4.0 (1.5)		
48	10.4 (5.2)	2.0 (0.6)	938 (286)	6.4 (0.4)	3.5 (1.9)	3.3 (2.6)		6.1 (0.4)

*Standard Deviation

TABLE A-23. PARAMETERS MONITORED IN SOIL SAMPLES FROM HIGH N CORN IN RYE IN 1978

Week	0-15 cm				15-30 cm			
	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	---ppm---				---ppm---			
16	3.3 (0.8)*	1.6 (0.4)	969 (719)	6.5 (0.2)	1.7 (0.3)	1.5 (0.4)	985 (302)	6.3 (0.4)
18	4.5 (2.7)	1.3 (1.7)			2.7 (0.8)	0.8 (0.5)		
20	5.7 (1.4)	1.7 (1.1)			2.8 (0.7)	1.7 (1.2)		
21	11.5 (3.1)	2.3 (2.4)			5.1 (1.0)	1.2 (1.0)		
22	5.3 (2.1)	4.6 (1.4)			1.9 (1.2)	4.9 (1.4)		
23	6.0 (2.2)	3.1 (3.5)			2.3 (1.2)	2.2 (0.8)		
24	3.5 (1.2)	4.2 (3.0)			1.3 (0.4)	4.4 (1.2)		
25	4.0 (1.3)	7.1 (3.5)			2.0 (1.1)	5.9 (1.7)		
26	2.4 (0.8)	1.7 (0.2)			0.9 (0.4)	1.6 (0.2)		
27	1.9 (2.1)	14.4 (3.9)			0.7 (0.2)	9.2 (4.4)		
28	1.6 (0.8)	8.7 (2.3)			0.6 (0.1)	7.7 (2.9)		
29	2.5 (0.3)	7.5 (3.8)			0.7 (0.1)	5.7 (2.5)		
30	5.0 (2.7)	6.5 (2.5)			3.1 (2.7)	6.8 (1.7)		
31	2.6 (1.2)	6.5 (4.4)			0.7 (0.2)	4.5 (1.4)		
32	7.8 (2.5)	6.2 (1.8)			2.6 (1.4)	7.3 (1.1)		
33	5.1 (1.9)	10.4 (3.0)			1.4 (0.5)	6.6 (2.2)		
34	1.8 (0.9)	11.4 (5.8)			1.7 (1.8)	5.2 (2.3)		
35	3.6 (1.1)	12.2 (6.4)			2.0 (0.6)	5.1 (2.9)		
36	2.8 (0.4)	7.0 (4.8)			1.0 (0.1)	4.2 (3.7)		
37	5.1 (5.1)	13.6 (3.2)			2.8 (2.4)	8.7 (3.8)		
38	2.7 (1.3)	8.3 (4.8)			1.3 (0.4)	4.4 (2.4)		
39	2.3 (1.1)	9.4 (4.4)			1.5 (0.9)	7.8 (4.7)		
40	2.6 (1.3)	6.6 (1.5)			1.7 (0.7)	4.9 (2.6)		
41	4.9 (1.2)	7.5 (8.8)			2.4 (0.6)	3.6 (2.4)		
42	2.8 (1.1)	5.2 (3.4)			2.0 (0.2)	6.0 (4.2)		
43	3.0 (1.8)	7.6 (1.3)			1.2 (0.3)	5.7 (1.4)		
44	4.3 (2.2)	2.4 (0.2)			1.6 (0.2)	2.1 (0.6)		
45	2.8 (1.4)	2.7 (1.4)			1.2 (0.4)	3.3 (1.6)		
46	1.9 (1.0)	3.6 (3.4)			1.9 (0.4)	3.4 (0.7)		
47	6.2 (2.9)	3.0 (1.8)			2.9 (1.5)	3.9 (1.6)		
48	11.4 (3.0)	1.4 (0.6)	1288 (543)	6.5 (0.1)	4.4 (4.4)	2.0 (0.8)		6.3 (0.4)

*Standard Deviation

TABLE A-24. PARAMETERS MONITORED IN SOIL SAMPLES FROM HIGH N RYEGRASS HAY IN 1978

Week	0-15 cm				15-30 cm			
	NO_3-N	NH_4-N	Kjeldahl N	pH	NO_3-N	NH_4-N	Kjeldahl N	pH
	ppm				ppm			
16	7.4 (1.6)*	1.5 (0.7)	1471 (488)	6.4 (0.2)	2.2 (1.0)	1.2 (0.5)	839 (394)	6.4 (0.3)
18	8.6 (3.1)	0.9 (1.0)			2.7 (0.9)	1.4 (0.7)		
20	6.5 (0.5)	1.5 (0.1)			2.7 (0.5)	1.0 (0.5)		
21	8.6 (2.8)	1.3 (0.9)			4.2 (1.5)	0.4 (0.6)		
22	1.6 (1.2)	5.2 (1.6)			1.0 (0.4)	4.6 (1.8)		
23	3.3 (1.6)	2.1 (0.6)			1.2 (0.3)	2.1 (0.5)		
24	1.3 (0.3)	6.4 (1.4)			0.7 (0.4)	4.9 (2.4)		
25	3.1 (0.7)	6.9 (1.5)			1.2 (0.4)	5.8 (2.3)		
26	1.4 (0.4)	2.7 (1.2)			0.8 (0.4)	1.3 (0.4)		
27	1.2 (1.2)	10.8 (0.9)			0.7 (0.2)	11.3 (8.3)		
28	0.9 (0.4)	7.3 (2.5)			0.6 (0.0)	5.7 (2.4)		
29	1.5 (0.4)	6.6 (5.2)			0.6 (0.0)	5.2 (1.7)		
30	5.0 (1.2)	5.4 (2.8)			1.2 (0.1)	3.0 (1.0)		
31	1.2 (0.4)	6.6 (4.1)			0.6 (0.1)	4.0 (0.7)		
32	4.8 (2.8)	7.8 (2.6)			1.6 (0.6)	6.9 (3.5)		
33	3.3 (2.2)	3.9 (5.0)			1.1 (0.4)	5.2 (4.9)		
34	1.7 (0.7)	8.2 (5.2)			1.0 (0.2)	5.1 (3.4)		
35	3.0 (0.8)	8.3 (5.0)			1.9 (0.5)	3.5 (3.5)		
36	1.6 (0.7)	4.0 (3.0)			1.2 (0.7)	7.3 (6.0)		
37	2.4 (0.4)	7.2 (2.0)			1.2 (0.4)	5.2 (3.4)		
38	2.5 (1.1)	10.1 (6.0)			1.1 (0.6)	7.1 (4.7)		
39	2.0 (0.7)	9.1 (2.2)			1.0 (0.4)	6.5 (3.3)		
40	2.0 (0.7)	5.6 (4.6)			1.2 (0.3)	4.5 (3.7)		
41	2.7 (1.4)	8.3 (6.8)			1.0 (0.2)	6.2 (4.9)		
42	1.6 (0.9)	5.0 (1.2)			1.3 (0.6)	5.2 (1.6)		
43	2.3 (1.8)	10.6 (3.7)			0.8 (0.4)	6.9 (2.0)		
44	2.2 (2.5)	2.6 (2.0)			1.2 (0.9)	1.7 (0.2)		
45	1.1 (0.4)	2.7 (1.0)			0.8 (0.2)	2.8 (1.1)		
46	1.2 (0.4)	3.0 (1.4)			2.4 (2.6)	2.0 (0.4)		
47	2.9 (1.2)	3.8 (1.6)			2.0 (0.6)	3.7 (2.4)		
48	7.2 (4.9)	2.1 (0.8)	1129 (579)	6.6 (0.2)	2.1 (1.5)	3.9 (2.3)		6.8 (0.3)

*Standard Deviation

TABLE A-25. PARAMETERS MONITORED IN SOIL SAMPLES FROM 7 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1978

Week	0-15 cm					
	NO_3-N	NH_4-N	Cl	Kjeldahl N	Spec. Cond.	pH
	ppm	ppm	ppm	ppm	umhos/cm	
16	3.0 (0.6)*	1.1 (0.4)	6.2 (0.1)	1504 (187)	620 (65)	6.2 (0.2)
18	6.7 (1.3)	1.2 (1.0)	1.2 (0.1)			
20	7.2 (1.8)	1.5 (0.2)	6.3 (0.2)			
21	13.1 (1.8)	1.5 (0.8)	12.5 (2.7)			
22	13.6 (8.8)	5.4 (1.6)	61.2 (23.2)	1637 (566)	1880 (603)	6.2 (0.2)
23	11.6 (4.2)	1.9 (1.4)	54.7 (13.9)			
24	7.8 (2.5)	4.1 (1.1)	51.0 (20.4)			
25	6.7 (1.5)	5.7 (0.8)	143.9 (10.0)			
26	3.8 (0.2)	1.8 (0.3)	32.2 (15.8)			
27	1.9 (1.4)	9.4 (3.0)	41.0 (10.6)	1637 (296)	1523 (171)	6.5 (0.1)
28	1.6 (0.7)	8.2 (3.4)	47.7 (15.9)			
29	2.9 (0.8)	4.6 (0.3)	53.5 (14.6)			
30	4.9 (2.0)	2.8 (1.4)	50.5 (13.6)			
31	1.2 (0.4)	4.8 (1.6)	57.4 (17.9)			
32	6.0 (2.0)	4.5 (1.7)	63.1 (26.7)	1475 (239)	1827 (325)	6.6 (0.3)
33	4.3 (1.6)	4.2 (3.7)	54.2 (8.4)			
34	1.6 (0.7)	6.4 (1.4)	46.7 (10.3)			
35	3.2 (1.2)	5.1 (3.7)	42.5 (10.1)			
36	2.2 (1.0)	6.3 (2.9)	49.8 (9.2)			
37	2.8 (0.5)	7.4 (1.7)	46.1 (29.7)	1377 (144)		6.6 (0.2)
38	2.9 (1.0)	6.5 (1.0)	16.4 (8.8)			
39	2.6 (0.9)	4.9 (2.2)	24.5 (16.1)			
40	3.4 (1.1)	5.7 (2.2)	22.0 (10.5)			
41	4.2 (1.1)	2.2 (0.9)	10.1 (3.4)			
42	2.2 (0.5)	5.4 (1.7)	9.1 (1.6)	1392 (159)	1287 (62)	6.4 (0.2)
43	2.2 (1.1)	6.5 (1.2)	19.0 (10.2)			
44	3.2 (0.6)	1.9 (0.4)	8.2 (2.3)			
45	2.8 (1.5)	2.0 (0.7)	8.8 (1.5)			
46	3.2 (1.3)	2.4 (0.6)	8.8 (1.7)			
47	5.1 (2.0)	4.0 (2.5)	6.8 (1.3)	1432 (578)	924 (196)	6.4 (0.3)
48	12.3 (1.8)	1.7 (0.4)	8.0 (2.1)	1097 (240)	1119 (134)	6.6 (0.2)

*Standard Deviation

(Continued)

TABLE A-25. (Continued)

Week	15-30 cm					
	NO_3-N	NH_4-N	Cl	Kjeldahl N	Spec. Cond.	pH
	ppm				umhos/cm	
16	1.3 (0.1)*	1.8 (0.3)	5.9 (0.1)	848 (356)	724 (395)	6.0 (0.2)
18	2.3 (0.7)	1.7 (2.8)	1.2 (0.0)			
20	4.6 (1.6)	1.4 (0.4)	6.0 (0.2)			
21	7.6 (3.0)	0.7 (0.8)	2.4 (0.6)			
22	4.8 (2.5)	4.2 (0.4)	20.3 (7.7)	1232 (254)	1184 (72)	6.1 (0.2)
23	3.8 (1.1)	1.6 (0.5)	38.7 (30.6)			
24	2.9 (1.6)	3.1 (1.2)	13.7 (3.3)			
25	5.0 (0.6)	4.6 (0.8)	127.4 (3.9)			
26	2.9 (0.2)	1.9 (0.5)	26.7 (1.8)			
27	1.3 (0.8)	6.5 (1.6)	27.3 (5.3)	1151 (753)	1144 (91)	6.0 (0.2)
28	0.9 (0.3)	5.3 (1.1)	25.5 (4.2)			
29	1.2 (0.1)	4.6 (0.6)	26.2 (3.8)			
30	1.9 (0.5)	3.9 (2.0)	30.1 (4.8)			
31	0.6 (0.0)	3.8 (1.1)	27.3 (1.7)			
32	1.8 (0.7)	5.6 (1.4)	27.8 (2.2)	762 (227)	1232 (104)	5.9 (0.4)
33	1.5 (0.4)	2.8 (2.5)	28.9 (4.9)			
34	1.5 (1.1)	3.8 (1.5)	32.8 (16.0)			
35	2.5 (0.8)	4.1 (2.2)	45.7 (4.2)			
36	1.0 (0.3)	3.6 (4.5)	33.3 (4.6)			
37	1.2 (0.3)	4.7 (2.2)	25.9 (8.0)	1183 (511)		6.1 (0.3)
38	1.6 (0.6)	3.7 (0.8)	20.9 (6.9)			
39	1.3 (0.4)	5.9 (2.6)	54.4 (42.8)			
40	1.6 (0.5)	2.9 (1.4)	24.2 (11.0)			
41	2.8 (2.0)	2.6 (0.6)	8.5 (1.0)			
42	1.9 (0.9)	3.7 (1.1)	10.6 (4.0)	1114 (505)	1214 (62)	6.2 (0.3)
43	1.2 (0.3)	5.1 (1.4)	20.4 (4.3)			
44	1.8 (0.6)	1.8 (0.4)	8.1 (2.7)			
45	1.8 (0.6)	2.1 (0.6)	8.0 (2.1)			
46	1.7 (0.5)	2.4 (1.0)	8.1 (1.9)			
47	3.2 (1.0)	3.3 (1.3)	6.6 (1.8)	581 (231)	829 (141)	6.4 (0.2)
48	4.7 (3.2)	3.2 (2.3)	7.6 (2.0)	398 (141)	825 (107)	6.4 (0.2)

*Standard Deviation

TABLE A-26. PARAMETERS MONITORED IN SOIL SAMPLES FROM 22 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1978

Week	0-15 cm					
	NO_3-N	NH_4-N	Cl	Kjeldahl N	Spec. Cond.	pH
	ppm	ppm	ppm	ppm	umhos/cm	
16	3.4 (1.1)*	1.1 (0.4)	6.3 (0.4)	1455 (541)	844 (118)	6.5 (0.2)
18	8.9 (5.3)	0.7 (0.8)	1.6 (0.9)			
20	5.8 (1.5)	1.2 (0.3)	6.0 (0.1)			
21	14.1 (1.5)	2.2 (1.3)	15.7 (6.3)			
22	13.7 (6.1)	4.9 (0.5)	67.6 (17.1)	1475 (683)	2333 (505)	6.3 (0.5)
23	11.9 (3.0)	1.5 (0.4)	59.6 (18.1)			
24	6.5 (2.6)	4.2 (1.6)	46.4 (18.8)			
25	5.8 (1.4)	4.6 (0.6)	131.9 (25.0)			
26	2.7 (0.7)	1.7 (0.5)	23.6 (12.3)			
27	1.9 (2.0)	7.9 (3.8)	33.6 (14.5)	1507 (431)	1400 (230)	6.9 (0.3)
28	1.9 (1.0)	6.9 (4.6)	39.4 (13.0)			
29	3.2 (0.7)	4.6 (2.0)	56.3 (12.6)			
30	5.2 (1.0)	3.3 (1.8)	37.7 (14.1)			
31	2.1 (0.3)	3.2 (1.1)	65.0 (51.6)			
32	5.8 (1.4)	4.4 (1.9)	50.2 (28.5)	1426 (218)	1771 (467)	6.8 (0.2)
33	3.8 (1.0)	6.0 (2.4)	58.3 (22.2)			
34	2.4 (1.5)	4.2 (1.9)	43.5 (12.2)			
35	3.6 (2.0)	8.9 (3.8)	36.2 (14.6)			
36	3.4 (1.8)	7.5 (4.9)	37.2 (18.4)			
37	4.8 (2.9)	4.3 (2.2)	28.5 (12.6)	1653 (786)		6.6 (0.1)
38	3.5 (0.4)	4.6 (2.1)	11.7 (3.9)			
39	3.1 (0.7)	4.4 (1.0)	19.2 (13.7)			
40	3.7 (1.4)	4.0 (3.0)	14.6 (6.4)			
41	4.7 (1.2)	2.1 (1.1)	8.0 (3.5)			
42	3.4 (1.3)	3.1 (1.5)	8.0 (1.3)	1535 (430)	1424 (236)	6.7 (0.2)
43	3.3 (0.3)	6.9 (1.6)	7.9 (1.7)			
44	4.3 (1.1)	1.7 (0.4)	6.4 (0.5)			
45	4.5 (1.7)	1.8 (0.3)	7.5 (2.0)			
46	2.5 (1.2)	2.0 (0.3)	9.6 (3.9)			
47	6.0 (2.8)	2.4 (1.1)	6.4 (0.4)	1114 (500)	890 (156)	6.8 (0.2)
48	9.7 (5.5)	2.1 (1.1)	9.1 (3.3)	1065 (790)	1217 (410)	6.5 (0.4)

*Standard Deviation

(Continued)

TABLE A-26. (Continued)

Week	15-30 cm					
	NO_3-N	NH_4-N	Cl	Kjeldahl N	Spec. Cond.	pH
	ppm				umhos/cm	
16	1.4 (0.4)*	1.4 (0.4)	5.9 (0.1)	807 (415)	1029 (630)	5.8 (0.3)
18	2.5 (1.7)	1.0 (0.9)	1.1 (0.0)			
20	2.8 (0.7)	1.4 (0.6)	5.8 (0.1)			
21	8.3 (2.2)	1.0 (0.2)	3.3 (1.4)			
22	4.8 (1.0)	3.5 (1.3)	24.6 (8.0)	1377 (522)	1197 (129)	6.0 (0.3)
23	4.2 (1.0)	1.7 (0.3)	19.3 (3.9)			
24	3.8 (1.2)	2.8 (0.2)	18.8 (4.7)			
25	5.3 (3.0)	4.4 (1.3)	140.2 (34.5)			
26	2.2 (0.6)	1.8 (0.6)	20.9 (9.1)			
27	1.1 (0.4)	5.3 (1.2)	23.3 (8.4)	956 (282)	1357 (451)	6.1 (0.5)
28	1.1 (0.3)	4.0 (0.6)	26.7 (5.9)			
29	1.4 (0.9)	3.8 (0.7)	25.5 (4.4)			
30	1.7 (0.2)	2.9 (1.8)	26.7 (3.7)			
31	0.6 (0.1)	2.9 (1.1)	29.4 (2.2)			
32	1.8 (1.1)	3.9 (1.3)	30.9 (6.6)	762 (296)	1251 (188)	6.0 (0.4)
33	1.4 (0.3)	2.4 (2.0)	31.4 (5.8)			
34	1.2 (0.3)	2.7 (0.7)	35.9 (10.1)			
35	1.9 (1.2)	4.2 (0.3)	35.7 (12.7)			
36	1.6 (1.0)	7.9 (4.2)	33.2 (12.6)			
37	1.6 (0.5)	4.1 (1.3)	16.8 (3.2)	632 (245)		6.2 (0.4)
38	1.4 (0.3)	2.8 (1.4)	13.8 (4.0)			
39	1.3 (0.5)	4.0 (1.2)	15.8 (6.5)			
40	2.4 (1.3)	2.6 (2.9)	19.5 (9.5)			
41	2.8 (0.9)	2.5 (1.7)	10.7 (5.1)			
42	2.2 (0.5)	4.0 (2.3)	8.3 (2.3)	907 (258)	1324 (286)	6.0 (0.3)
43	2.1 (0.8)	8.6 (3.8)	8.8 (3.5)			
44	2.5 (0.8)	2.1 (0.6)	6.3 (0.3)			
45	2.1 (0.9)	1.8 (0.4)	7.5 (2.4)			
46	2.8 (0.7)	2.6 (1.0)	9.6 (6.1)			
47	2.7 (0.9)	2.1 (0.3)	6.1 (0.8)	708 (461)	804 (209)	6.4 (0.4)
48	4.2 (4.3)	2.1 (0.5)	7.9 (3.5)	620 (502)	785 (259)	6.4 (0.4)

*Standard Deviation

TABLE A-27. PARAMETERS MONITORED IN SOIL SAMPLES FROM N-STRIPPING PLOTS IN 1977

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	ppm					meq/100 g
				Low N Corn			
19	0-15	368 (66)*	60 (5)	81 (7)	52 (12)	7 (2)	
19	15-30	112 (79)	15 (7)	55 (13)	21 (10)	4 (2)	
47	0-15	532 (269)	55 (30)	82 (22)	34 (21)	15 (2)	
47	15-30	150 (130)	13 (14)	71 (13)	20 (12)	13 (3)	
47	30-45	88 (57)	5 (6)	51 (8)	15 (6)	14 (5)	
47	45-60	60 (36)	5 (6)	41 (11)	9 (1)	12 (4)	
47	60-75	47 (38)	3 (2)	37 (10)	8 (2)	12 (5)	
				Low N Corn in Rye			
19	0-15	423 (104)	63 (12)	81 (3)	52 (7)	12 (4)	1.2 (0.1)
19	15-30	228 (118)	28 (20)	53 (9)	23 (2)	5 (2)	
47	0-15	784 (114)	85 (13)	91 (21)	49 (15)	15 (6)	
47	15-30	378 (97)	39 (12)	74 (15)	25 (9)	11 (1)	
47	30-45	238 (105)	20 (10)	54 (7)	16 (2)	15 (3)	
47	45-60	118 (88)	8 (10)	43 (4)	12 (3)	15 (5)	
47	60-75	86 (55)	4 (5)	37 (7)	9 (2)	13 (4)	
				Low N Corn in Ryegrass			
19	0-15	484 (181)	65 (27)	91 (31)	57 (12)	7 (2)	
19	15-30	169 (62)	23 (9)	59 (9)	20 (2)	4 (0)	
47	0-15	602 (134)	68 (10)	80 (28)	36 (7)	14 (3)	
47	15-30	318 (125)	34 (12)	71 (33)	24 (13)	12 (1)	
47	30-45	172 (87)	13 (10)	51 (14)	14 (6)	11 (3)	
47	45-60	106 (75)	6 (5)	45 (15)	13 (7)	11 (3)	
47	60-75	91 (59)	6 (8)	39 (13)	9 (3)	11 (3)	

*Standard Deviation

(Continued)

TABLE A-27. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	-----	-----	ppm	-----	-----	meq/100 g
				Low N Ryegrass Hay			
19	0-15	450 (172)*	62 (16)	71 (7)	48 (10)	16 (5)	
19	15-30	212 (77)	26 (9)	54 (8)	22 (4)	8 (2)	
47	0-15	583 (206)	54 (19)	79 (13)	25 (7)	16 (4)	
47	15-30	210 (143)	18 (16)	54 (17)	11 (4)	12 (3)	
47	30-45	205 (164)	18 (18)	53 (15)	11 (3)	14 (5)	
47	45-60	125 (75)	8 (8)	47 (9)	9 (3)	13 (6)	
47	60-75	87 (23)	5 (2)	40 (3)	7 (2)	12 (8)	
				High N Corn			
19	0-15	506 (188)	62 (31)	26 (8)	59 (16)	10 (6)	
19	15-30	209 (115)	25 (16)	26 (10)	19 (7)	5 (3)	
47	0-15	1007 (341)	90 (32)	104 (7)	49 (18)	17 (5)	
47	15-30	349 (192)	30 (23)	64 (6)	18 (7)	10 (3)	
47	30-45	190 (106)	16 (14)	57 (9)	13 (2)	10 (3)	
47	45-60	223 (219)	19 (21)	53 (11)	10 (4)	11 (4)	
47	60-75	180 (158)	21 (26)	58 (10)	9 (1)	8 (2)	
				High N Corn in Rye			
19	0-15	655 (234)	95 (33)	29 (12)	65 (14)	6 (3)	
19	15-30	331 (159)	60 (29)	24 (4)	24 (6)	3 (1)	
47	0-15	958 (411)	103 (35)	117 (35)	71 (25)	11 (4)	
47	15-30	539 (315)	52 (36)	88 (27)	34 (20)	9 (3)	
47	30-45	343 (215)	30 (24)	69 (12)	20 (11)	9 (4)	
47	45-60	136 (33)	10 (7)	47 (10)	8 (4)	9 (5)	
47	60-75	92 (51)	9 (8)	50 (13)	7 (2)	10 (6)	

*Standard Deviation

(Continued)

TABLE A-27. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	-------------------------------	------------	ppm	------------	-------------------------------	meq/100 g
				High N Ryegrass Hay			
19	0-15	659 (277)*	78 (36)	32 (12)	53 (24)	8 (1)	
19	15-30	673 (256)	93 (40)	33 (19)	44 (33)	5 (2)	
47	0-15	993 (187)	101 (24)	135 (33)	68 (54)	12 (4)	
47	15-30	356 (214)	34 (27)	78 (30)	21 (17)	8 (2)	
47	30-45	277 (166)	26 (19)	63 (17)	15 (12)	10 (5)	
47	45-60	215 (166)	20 (19)	57 (5)	10 (7)	8 (3)	
47	60-75	162 (65)	17 (9)	51 (5)	9 (2)	8 (1)	
				7 T/Ha Sludge Applied to High N Corn			
19	0-15	511 (79)	68 (6)	23 (3)	61 (7)	9 (6)	1.2 (0.1)
19	15-30	233 (58)	34 (20)	23 (3)	22 (3)	6 (2)	
47	0-15	986 (333)	86 (23)	100 (31)	46 (19)	16 (9)	1.3 (0.6)
47	15-30	538 (508)	55 (65)	62 (13)	18 (9)	12 (4)	
47	30-45	153 (20)	14 (3)	52 (15)	10 (4)	10 (5)	
47	45-60	106 (48)	8 (4)	40 (14)	7 (1)	8 (5)	
47	60-75	100 (46)	9 (5)	39 (12)	8 (1)	9 (4)	
				22 T/Ha Sludge Applied to High N Corn			
19	0-15	681 (206)	80 (40)	33 (15)	63 (14)	19 (12)	1.4 (0.2)
19	15-30	287 (192)	36 (36)	29 (16)	20 (3)	7 (4)	
47	0-15	815 (253)	64 (27)	100 (28)	40 (8)	19 (7)	1.4 (0.2)
47	15-30	472 (232)	40 (24)	74 (21)	20 (8)	13 (4)	
47	30-45	270 (239)	23 (30)	56 (9)	13 (5)	10 (3)	
47	45-60	152 (186)	18 (22)	41 (35)	8 (4)	11 (6)	
47	60-75	118 (137)	13 (15)	38 (20)	9 (3)	10 (4)	

*Standard Deviation

TABLE A-28. PARAMETERS MONITORED IN SOIL SAMPLES FROM N-STRIPPING PLOTS IN 1978

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	----------ppm----------					meq/100 g
				Low N Corn			
15	0-15	1037 (399)*	117 (45)	71 (7)	43 (11)	13 (2)	
15	15-30	326 (277)	32 (29)	77 (19)	20 (6)	10 (2)	
15	30-45	239 (312)	14 (24)	57 (13)	12 (4)	10 (2)	
48	0-15	581 (457)	84 (64)	91 (37)	32 (19)	15 (12)	
48	15-30	152 (62)	30 (20)	66 (19)	14 (3)	4 (2)	
48	30-45	102 (68)	12 (9)	60 (29)	11 (3)	3 (1)	
48	45-60	63 (44)	7 (6)	51 (28)	7 (2)	3 (1)	
48	60-75	52 (50)	31 (51)	66 (56)	17 (21)	7 (3)	
48	75-90	55 (36)	6 (7)	40 (20)	8 (2)	11 (9)	
				Low N Corn in Rye			
15	0-15	950 (411)	109 (59)	62 (18)	55 (35)	15 (5)	
15	15-30	552 (509)	54 (60)	63 (9)	32 (28)	9 (2)	
15	30-45	260 (163)	17 (15)	59 (5)	14 (4)	11 (1)	
48	0-15	460 (215)	72 (34)	84 (12)	33 (11)	13 (9)	
48	15-30	162 (69)	28 (16)	67 (22)	14 (2)	3 (2)	
48	30-45	334 (277)	52 (34)	92 (41)	28 (25)	4 (2)	
48	45-60	125 (64)	15 (11)	59 (25)	15 (6)	3 (1)	
48	60-75	247 (372)	29 (45)	67 (42)	18 (19)	3 (0)	
48	75-90	94 (81)	10 (10)	58 (30)	8 (3)	6 (2)	

*Standard Deviation

(Continued)

TABLE A-28. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	ppm					meq/100 g
				Low N Corn in Ryegrass			
15	0-15	1107 (510)*	138 (69)	80 (18)	84 (21)	13 (4)	
15	15-30	462 (307)	47 (37)	85 (27)	27 (10)	9 (2)	
15	30-45	233 (112)	13 (10)	65 (19)	13 (2)	10 (2)	
48	0-15	548 (339)	96 (59)	81 (14)	44 (32)	15 (4)	
48	15-30	196 (92)	41 (32)	54 (25)	24 (16)	7 (4)	
48	30-45	162 (79)	28 (19)	51 (26)	20 (10)	8 (5)	
48	45-60	107 (46)	15 (10)	54 (21)	12 (5)	5 (2)	
48	60-75	92 (45)	13 (9)	51 (23)	9 (3)	5 (4)	
48	75-90	135 (63)	14 (3)	47 (19)	10 (3)	7 (6)	
				Low N Ryegrass Hay			
15	0-15	1259 (120)	132 (38)	73 (5)	91 (45)	20 (9)	
15	15-30	621 (357)	67 (46)	69 (19)	31 (32)	9 (3)	
15	30-45	305 (162)	23 (11)	53 (4)	14 (6)	9 (3)	
48	0-15	642 (414)	112 (80)	119 (31)	46 (28)	24 (18)	
48	15-30	243 (166)	47 (46)	80 (38)	20 (20)	7 (4)	
48	30-45	260 (211)	41 (28)	85 (26)	23 (11)	17 (25)	
48	45-60	95 (31)	17 (17)	49 (18)	10 (4)	9 (8)	
48	60-75	131 (90)	19 (26)	52 (21)	9 (6)	10 (11)	
48	75-90	132 (94)	21 (22)	56 (20)	9 (6)	11 (7)	

*Standard Deviation

(Continued)

TABLE A-28. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	ppm					meq/100 g
				High N Corn			
16	0-15	1081 (269)*	108 (34)	89 (28)	76 (13)	16 (6)	
16	15-30	703 (335)	59 (33)	82 (18)	34 (8)	11 (4)	
16	30-45	304 (170)	20 (20)	58 (10)	18 (3)	10 (5)	
48	0-15	451 (208)	77 (35)	80 (28)	44 (25)	13 (6)	
48	15-30	232 (163)	28 (18)	72 (11)	25 (15)	9 (7)	
48	30-45	87 (35)	8 (6)	47 (14)	12 (5)	7 (3)	
48	45-60	94 (44)	10 (7)	45 (16)	9 (3)	12 (11)	
48	60-75	107 (84)	14 (17)	49 (19)	7 (3)	13 (8)	
48	75-90	110 (68)	20 (16)	51 (21)	8 (3)	14 (5)	
				High N Corn in Rye			
16	0-15	1223 (399)	149 (46)	85 (22)	97 (10)	12 (4)	
16	15-30	726 (400)	77 (44)	91 (35)	42 (0)	8 (1)	
16	30-45	493 (171)	43 (21)	71 (21)	20 (5)	6 (2)	
48	0-15	563 (219)	105 (33)	102 (37)	52 (23)	7 (2)	
48	15-30	188 (46)	34 (17)	67 (13)	18 (5)	4 (2)	
48	30-45	148 (64)	25 (14)	58 (5)	12 (2)	7 (7)	
48	45-60	103 (37)	13 (10)	52 (74)	8 (3)	8 (7)	
48	60-75	92 (49)	12 (10)	53 (26)	7 (4)	9 (4)	
48	75-90	88 (45)	10 (9)	46 (21)	6 (2)	12 (7)	

*Standard Deviation

(Continued)

TABLE A-28. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	-----------	-----------	ppm	-----------	-----------	meq/100 g
				High N Ryegrass Hay			
16	0-15	1393 (742)*	165 (84)	76 (12)	90 (44)	11 (3)	
16	15-30	633 (369)	60 (34)	82 (24)	27 (14)	8 (1)	
16	30-45	335 (202)	31 (28)	62 (18)	13 (7)	6 (1)	
48	0-15	489 (432)	68 (52)	81 (33)	20 (21)	6 (2)	
48	15-30	259 (157)	40 (24)	82 (18)	15 (11)	4 (2)	
48	30-45	137 (80)	19 (13)	64 (10)	11 (3)	5 (2)	
48	45-60	321 (186)	54 (38)	90 (28)	32 (30)	7 (2)	
48	60-75	147 (72)	21 (12)	67 (9)	17 (11)	8 (2)	
48	75-90	113 (45)	13 (8)	60 (4)	10 (5)	9 (3)	
				7 T/Ha Sludge Applied to High N Corn			
16	0-15	1214 (177)	108 (24)	86 (10)	59 (9)	13 (4)	2.9 (0.8)
16	15-30	404 (279)	27 (30)	66 (19)	21 (8)	9 (1)	
16	30-45	340 (146)	22 (16)	52 (8)	13 (5)	8 (1)	
48	0-15	455 (279)	82 (52)	73 (12)	35 (15)	15 (6)	2.2 (0.3)
48	15-30	292 (391)	40 (52)	63 (45)	10 (4)	4 (3)	
48	30-45	102 (23)	15 (9)	45 (19)	9 (3)	5 (2)	
48	45-60	187 (186)	35 (41)	60 (36)	18 (22)	8 (7)	
48	60-75	91 (22)	15 (6)	48 (6)	9 (3)	9 (2)	
48	75-90	87 (23)	15 (7)	50 (8)	9 (2)	12 (9)	

*Standard Deviation

(Continued)

TABLE A-28. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	CEC
	cm	----------	----------	ppm	----------	----------	meq/100 g
				22 T/Ha Sludge Applied to High N Corn			
16	0-15	1168 (470)	109 (50)	70 (23)	53 (24)	29 (18)	2.3 (1.2)
16	15-30	631 (273)	45 (36)	70 (21)	27 (14)	10 (2)	
16	30-45	439 (291)	28 (38)	52 (16)	14 (7)	11 (6)	
48	0-15	608 (440)	93 (64)	84 (44)	31 (29)	21 (9)	2.3 (0.9)
48	15-30	292 (391)	40 (52)	63 (45)	10 (4)	4 (3)	
48	30-45	345 (542)	49 (85)	64 (57)	9 (1)	5 (4)	
48	45-60	179 (240)	23 (41)	45 (27)	12 (12)	9 (5)	
48	60-75	139 (108)	17 (18)	44 (15)	12 (8)	12 (4)	
48	75-90	105 (95)	11 (15)	47 (24)	8 (2)	12 (6)	

*Standard Deviation

TABLE A-29. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	5.5 (4.2)*	0.1 (0.1)	0.7 (0.2)	357 (99)	8.7 (6.4)
21	7.3 (4.0)	0.1 (0.2)		300 (104)	
22	6.3 (2.8)	0.1 (0.1)		361 (128)	
23	7.2 (4.2)	0.1 (0.0)		344 (126)	
24	10.1 (5.3)	0.1 (0.1)	1.3 (0.3)	237 (134)	14.1 (9.5)
25	8.6 (5.1)	0.2 (0.1)		155 (56)	
26	12.1 (6.4)	0.2 (0.1)		158 (62)	
27	18.2 (7.8)	0.2 (0.2)		187 (56)	
28	15.7 (8.7)	0.2 (0.2)		193 (58)	
29	17.8 (10.1)	0.4 (0.5)	1.2 (0.6)	236 (43)	13.5 (6.0)
30	20.7 (10.1)	0.6 (0.9)		239 (16)	
31	17.5 (5.7)	0.2 (0.6)		239 (42)	
32	17.8 (6.8)	0.3 (0.3)		243 (26)	
33	6.3 (5.8)	0.2 (0.1)		239 (24)	
34	6.5 (6.0)	0.1 (0.1)	1.7 (0.7)	210 (25)	
35	7.6 (5.6)	0.2 (0.6)		289 (24)	
36	7.6 (5.4)	0.3 (0.8)		257 (23)	
37	10.1 (5.3)	0.3 (0.8)		308 (31)	
38	11.2 (8.0)	0.2 (0.4)		218 (32)	
39	10.0 (7.0)	0.2 (0.5)	1.0 (0.7)	262 (23)	
40	8.9 (5.7)	0.5 (0.1)		203 (19)	
41	7.7 (6.0)	0.1 (0.1)		196 (24)	
42	7.8 (6.6)	0.3 (0.9)		218 (25)	
43	6.6 (7.3)	0.1 (0.2)		232 (15)	
44	4.5 (2.2)	0.1 (0.1)	1.9 (1.5)	200 (45)	
45	3.8 (2.2)	0.1 (0.1)		196 (36)	
46	3.9 (2.3)	ND**	1.5 (0.7)	186 (33)	

*Standard Deviation **Not Detectable

TABLE A-30. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN RYE IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	3.3 (2.2)*	0.4 (0.3)	0.8 (0.2)	348 (78)	8.3 (3.7)
21	4.7 (3.5)	0.2 (0.3)		267 (82)	
22	4.5 (3.4)	0.2 (0.1)		365 (122)	
23	5.0 (3.2)	0.1 (0.1)		291 (85)	
24	6.0 (4.1)	0.1 (0.3)	1.8 (0.9)	241 (74)	17.0 (9.4)
25	6.9 (3.3)	0.2 (0.1)		162 (48)	
26	6.3 (3.3)	0.3 (0.4)		197 (43)	
27	7.7 (5.7)	0.3 (0.6)		223 (74)	
28	7.3 (4.3)	0.3 (0.3)		241 (35)	
29	9.0 (6.0)	0.4 (0.4)	1.4 (0.7)	257 (16)	13.5 (6.2)
30	8.4 (4.5)	0.2 (0.1)		244 (22)	
31	10.0 (6.2)	0.1 (0.1)		266 (24)	
32	9.2 (5.7)	0.3 (0.1)		257 (15)	
33	3.3 (1.9)	0.1 (0.1)		254 (21)	
34	3.4 (1.8)	0.1 (0.1)	1.7 (0.4)	216 (15)	
35	2.9 (1.6)	0.1 (0.1)		296 (19)	
36	3.0 (1.9)	0.1 (0.1)		253 (24)	
37	3.4 (2.2)	0.1 (0.1)		315 (26)	
38	3.4 (1.8)	0.1 (0.1)		232 (34)	
39	3.1 (2.2)	0.1 (0.1)	1.3 (0.5)	282 (34)	
40	4.3 (4.8)	0.2 (0.3)		197 (20)	
41	3.8 (3.4)	ND**		196 (15)	
42	3.7 (3.2)	0.2 (0.4)		222 (20)	
43	3.2 (2.3)	0.1 (0.1)		237 (16)	
44	4.8 (4.1)	0.1 (0.1)	1.7 (0.7)	202 (30)	
45	4.4 (2.4)	0.1 (0.1)		201 (34)	
46	2.4 (2.3)	0.1 (0.1)	1.3 (0.5)	190 (25)	

*Standard Deviation **Not Detectable

TABLE A-31. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN RYEGRASS IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	0.4 (0.4)*	0.2 (0.3)	1.2 (0.6)	303 (151)	22.9 (17.9)
21	1.9 (2.2)	0.1 (0.2)		204 (121)	
22	2.1 (1.5)	0.1 (0.1)		207 (123)	
23	1.7 (1.6)	0.1 (0.1)		219 (106)	
24	2.1 (1.4)	0.1 (0.1)	1.9 (0.9)	238 (92)	31.0 (23.2)
25	2.0 (1.8)	0.2 (0.2)		204 (49)	
26	1.9 (1.5)	0.1 (0.1)		212 (63)	
27	2.8 (2.2)	0.4 (0.5)		200 (82)	
28	3.1 (3.0)	0.2 (0.2)		206 (74)	
29	5.4 (4.4)	0.2 (0.2)	1.7 (0.7)	226 (71)	20.5 (11.7)
30	4.4 (3.0)	0.2 (0.1)		240 (50)	
31	5.1 (3.5)	0.1 (0.1)		256 (56)	
32	6.7 (5.6)	0.3 (0.1)		264 (47)	
33	3.1 (2.3)	0.1 (0.1)		273 (16)	
34	3.3 (3.1)	0.1 (0.2)	2.0 (0.6)	230 (21)	
35	3.2 (2.3)	0.1 (0.1)		310 (25)	
36	2.3 (1.7)	0.2 (0.1)		263 (40)	
37	2.4 (1.6)	0.1 (0.1)		321 (42)	
38	2.1 (1.7)	ND**		219 (21)	
39	2.5 (1.6)	ND	1.3 (0.5)	278 (17)	
40	3.7 (2.9)	0.2 (0.6)		202 (18)	
41	3.2 (2.2)	0.6 (0.1)		205 (20)	
42	3.3 (3.8)	0.1 (0.1)		219 (24)	
43	1.9 (1.8)	ND		244 (18)	
44	3.1 (1.9)	0.1 (0.1)	2.0 (1.4)	204 (33)	
45	2.6 (1.9)	0.1 (0.1)		202 (41)	
46	2.5 (2.1)	0.1 (0.1)	1.9 (0.7)	195 (30)	

* Standard Deviation **Not Detectable

TABLE A-32. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N RYEGRASS IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	1.5 (1.6)*	0.2 (0.2)	0.8 (0.6)	344 (91)	9.6 (6.2)
21	1.3 (1.3)	0.1 (0.1)		275 (114)	
22	1.0 (0.8)	0.1 (0.1)		395 (159)	
23	1.0 (0.8)	0.1 (0.1)		339 (120)	
24	1.5 (1.0)	0.1 (0.1)	1.7 (0.6)	342 (224)	24.0 (17.1)
25	1.2 (0.9)	0.2 (0.1)		173 (83)	
26	1.2 (0.8)	0.2 (0.1)		192 (81)	
27	1.8 (1.4)	0.2 (0.1)		254 (81)	
28	2.4 (2.8)	0.2 (0.1)		255 (62)	
29	3.5 (3.7)	0.2 (0.2)	1.6 (0.6)	307 (22)	20.2 (9.6)
30	3.5 (5.0)	0.2 (0.1)		284 (37)	
31	2.7 (2.8)	0.1 (0.1)		310 (62)	
32	6.3 (8.8)	0.4 (0.4)		319 (35)	
33	3.1 (3.2)	0.2 (0.2)		293 (31)	
34	2.5 (1.7)	0.1 (0.1)	2.1 (0.6)	227 (37)	
35	2.2 (2.2)	0.1 (0.1)		300 (26)	
36	2.4 (3.0)	0.1 (0.1)		247 (34)	
37	2.6 (3.2)	0.1 (0.1)		323 (37)	
38	1.2 (1.5)	ND**		227 (32)	
39	1.3 (2.0)	0.1 (0.1)	1.3 (0.6)	271 (38)	
40	1.9 (2.4)	0.1 (0.1)		204 (21)	
41	1.6 (2.8)	0.2 (0.3)		197 (19)	
42	2.1 (3.2)	0.1 (0.2)		213 (32)	
43	2.3 (4.4)	0.1 (0.2)		239 (32)	
44	1.4 (1.0)	0.2 (0.2)	2.4 (1.7)	208 (30)	
45	1.0 (0.7)	0.1 (0.1)		189 (34)	
46	1.1 (0.7)	ND	1.5 (0.8)	180 (20)	

*Standard Deviation **Not Detectable

TABLE A-33. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N CORN IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	10.4 (10.7)*	0.3 (0.4)	0.8 (0.2)	58 (42)	6.5 (3.9)
21	9.9 (8.4)	0.3 (0.7)		57 (61)	
22	13.9 (9.3)	0.3 (0.3)		91 (84)	
23	10.8 (6.7)	0.3 (0.3)		73 (80)	
24	17.1 (11.3)	0.2 (0.1)	1.2 (0.9)	174 (171)	10.1 (9.0)
25	23.4 (11.6)	0.2 (0.2)		202 (126)	
26	28.6 (17.3)	0.2 (0.2)		136 (77)	
27	37.1 (20.4)	0.4 (0.5)		201 (95)	
28	25.0 (13.6)	0.8 (1.1)		257 (65)	
29	23.0 (16.3)	0.6 (1.1)	2.2 (1.9)	252 (44)	19.4 (11.0)
30	28.5 (14.7)	0.7 (1.1)		232 (63)	
31	24.0 (13.7)	0.4 (0.8)		227 (88)	
32	20.2 (15.0)	0.7 (1.1)		210 (63)	
33	8.9 (10.5)	0.8 (1.7)		250 (41)	
34	8.2 (8.8)	0.5 (0.7)	1.9 (0.9)	208 (48)	
35	9.1 (10.2)	0.5 (1.1)		319 (51)	
36	13.8 (10.7)	0.6 (1.7)		241 (55)	
37	15.0 (11.2)	0.9 (2.1)		302 (59)	
38	14.1 (10.2)	0.1 (0.1)		226 (23)	
39	16.6 (14.9)	0.3 (0.8)	2.3 (1.6)	249 (30)	
40	14.9 (15.2)	0.3 (0.6)		214 (30)	
41	10.6 (7.3)	0.3 (0.9)		268 (31)	
42	9.9 (8.0)	0.1 (0.1)		248 (39)	
43	10.7 (8.1)	0.2 (0.6)		233 (29)	
44	10.2 (7.5)	0.4 (0.7)	2.3 (1.7)	179 (38)	
45	7.3 (3.9)	0.1 (0.1)		152 (35)	
46	7.3 (3.7)	0.1 (0.1)	1.4 (0.3)	157 (29)	
47	7.1 (2.6)	0.2 (0.2)		160 (26)	

*Standard Deviation

TABLE A-34. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N CORN IN RYE IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	5.9 (5.9)*	0.1 (0.1)	1.1 (1.0)	75 (58)	11.0 (8.9)
21	5.5 (4.6)	0.1 (0.2)		55 (56)	
22	7.6 (3.9)	0.2 (0.1)		80 (96)	
23	6.4 (3.9)	0.3 (0.2)		83 (104)	
24	9.8 (6.5)	0.3 (0.6)	1.3 (1.4)	168 (193)	9.2 (7.8)
25	8.9 (4.0)	0.2 (0.3)		167 (139)	
26	13.4 (8.2)	0.2 (0.2)		116 (60)	
27	16.7 (6.8)	0.2 (0.2)		163 (83)	
28	15.1 (8.0)	0.7 (1.0)		273 (42)	
29	15.7 (10.3)	0.7 (1.0)	1.8 (1.0)	286 (24)	18.0 (11.2)
30	16.2 (9.2)	0.4 (0.3)		286 (37)	
31	18.4 (8.7)	0.2 (0.2)		283 (84)	
32	14.7 (10.2)	0.4 (0.2)		280 (47)	
33	12.9 (12.3)	0.5 (1.2)		282 (22)	
34	13.8 (12.8)	0.6 (0.4)	2.2 (1.3)	244 (19)	
35	13.4 (12.4)	0.3 (0.4)		353 (18)	
36	13.5 (12.6)	0.3 (0.5)		266 (17)	
37	20.2 (19.5)	0.3 (0.4)		314 (56)	
38	14.4 (10.7)	0.1 (0.2)		237 (29)	
39	13.4 (10.0)	0.2 (0.6)	1.9 (2.0)	247 (36)	
40	9.9 (7.3)	0.2 (0.2)		216 (38)	
41	10.2 (8.5)	0.1 (0.2)		250 (61)	
42	12.1 (10.8)	0.1 (0.1)		243 (44)	
43	12.0 (10.1)	0.3 (0.8)		231 (47)	
44	11.2 (8.4)	0.3 (0.8)	2.1 (1.6)	184 (46)	
45	7.7 (4.8)	0.2 (0.1)		169 (53)	
46	9.0 (5.2)	0.3 (0.9)	1.5 (0.6)	170 (48)	
47	9.5 (6.9)	0.3 (0.5)		178 (34)	

*Standard Deviation

TABLE A-35. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N RYEGRASS IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
20	11.6 (5.7)*	0.2 (0.1)	0.7 (0.4)	91 (95)	5.5 (4.8)
21	9.7 (5.3)	ND**		57 (85)	
22	10.2 (5.2)	0.2 (0.2)		63 (47)	
23	10.2 (7.4)	0.2 (0.1)		77 (114)	
24	8.5 (3.6)	0.4 (0.7)	1.7 (1.4)	167 (152)	10.8 (5.8)
25	6.8 (4.4)	0.6 (1.6)		189 (142)	
26	8.7 (8.9)	0.9 (2.1)		148 (73)	
27	6.5 (6.8)	0.4 (0.4)		199 (81)	
28	7.1 (6.9)	0.8 (1.5)		274 (44)	
29	4.6 (5.8)	1.6 (2.0)	3.2 (1.9)	244 (46)	24.2 (7.8)
30	6.6 (6.1)	2.4 (4.1)		247 (41)	
31	8.1 (10.7)	1.2 (3.2)		202 (118)	
32	5.8 (6.5)	0.8 (1.2)		255 (61)	
33	9.4 (14.7)	1.7 (2.5)		295 (55)	
34	2.4 (2.2)	1.0 (2.1)	3.9 (3.3)	230 (15)	
35	2.8 (3.5)	1.0 (1.5)		339 (16)	
36	3.5 (3.4)	0.5 (0.8)		264 (39)	
37	3.4 (4.0)	0.5 (0.5)		324 (62)	
38	3.1 (4.8)	0.2 (0.4)		222 (36)	
39	3.7 (4.8)	0.2 (0.3)	1.5 (0.6)	240 (31)	
40	3.1 (7.4)	0.6 (0.5)		193 (31)	
41	2.4 (3.4)	0.2 (0.2)		248 (46)	
42	2.7 (2.3)	0.2 (0.2)		265 (37)	
43	3.0 (3.3)	0.8 (2.2)		229 (48)	
44	2.6 (2.0)	0.7 (1.0)	3.2 (2.1)	173 (40)	
45	1.1 (1.1)	0.3 (0.8)		175 (15)	
46	2.2 (2.5)	0.1 (0.2)	2.3 (1.6)	182 (28)	
47	2.2 (2.7)	0.3 (0.6)		174 (32)	

*Standard Deviation **Not Detectable

TABLE A-36. PARAMETERS MONITORED IN WELL SAMPLES FROM 7 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C	Spec. Cond.	pH
	---------------	-------- ppm --------			---------------	umhos/cm	
20	8.5 (5.1)*	0.2 (0.3)	1.6 (0.7)	58 (35)	13.2 (6.6)	253 (153)	5.4 (1.0)
21	11.5 (8.1)	0.1 (0.2)		31 (31)			
22	12.5 (6.7)	0.2 (0.2)		79 (102)			
23	13.0 (7.3)	0.2 (0.1)		70 (108)			
24	17.8 (9.6)	0.1 (0.1)	2.0 (1.6)	101 (137)	16.7 (13.6)	311 (190)	5.6 (0.9)
25	31.0 (17.4)	0.2 (0.1)		116 (115)			
26	32.2 (16.0)	0.2 (0.2)		104 (70)			
27	41.7 (20.0)	0.2 (0.3)		186 (62)			
28	33.4 (16.0)	0.4 (0.8)		283 (116)			
29	24.6 (15.4)	0.6 (1.2)	2.4 (2.6)	248 (87)	21.4 (21.0)	1134 (378)	5.7 (0.5)
30	29.5 (19.7)	1.5 (3.0)		245 (69)			
31	26.4 (17.3)	0.9 (2.5)		253 (74)			
32	22.8 (16.2)	0.8 (1.7)		236 (64)			
33	15.1 (15.5)	0.2 (0.2)		286 (61)			
34	13.0 (14.4)	0.3 (0.6)	2.0 (1.3)	223 (21)		1009 (109)	5.6 (0.5)
35	16.6 (17.7)	0.6 (1.6)		319 (19)			
36	16.2 (15.3)	0.2 (0.4)		238 (48)			
37	17.7 (20.5)	0.3 (0.4)		272 (75)			
38	10.3 (7.6)	0.3 (0.5)		210 (37)			
39	10.7 (8.2)	0.2 (0.4)	1.7 (1.0)	239 (47)		812 (123)	5.8 (0.4)
40	13.8 (14.8)	0.5 (0.6)		205 (43)			
41	13.6 (14.1)	0.1 (0.1)		240 (57)			
42	11.7 (11.5)	0.2 (0.5)		235 (37)			
43	11.9 (11.3)	0.2 (0.7)		217 (38)			
44	10.6 (13.4)	0.5 (1.2)	2.6 (3.0)	169 (40)		699 (126)	5.2 (0.9)
45	10.0 (10.4)	0.3 (0.5)		142 (45)			
46	9.2 (8.8)	0.1 (0.3)	1.9 (0.7)	148 (31)		659 (108)	5.7 (0.6)
47	9.6 (6.2)	0.4 (0.4)		178 (34)			

*Standard Deviation

TABLE A-37. PARAMETERS MONITORED IN WELL SAMPLES FROM 22 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1977

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C	Spec. Cond.	pH
	ppm					umhos/cm	
20	11.0 (8.5)*	0.3 (0.2)	3.0 (2.2)	100 (93)	28.5 (16.9)	328 (204)	5.8 (1.2)
21	13.4 (12.1)	0.1 (0.1)		58 (66)			
22	17.8 (17.2)	0.2 (0.1)		101 (119)			
23	13.9 (13.1)	0.2 (0.1)		78 (121)			
24	16.8 (20.1)	0.2 (0.2)	1.8 (1.7)	153 (228)	16.2 (11.2)	424 (388)	6.0 (1.0)
25	28.1 (15.4)	0.2 (0.2)		151 (135)			
26	35.8 (19.0)	0.3 (0.6)		89 (69)			
27	55.5 (45.0)	0.3 (0.3)		168 (64)			
28	43.1 (27.9)	0.4 (0.3)		230 (80)			
29	39.5 (25.3)	0.9 (1.5)	1.7 (1.1)	253 (83)	20.6 (14.4)	1151 (402)	5.6 (0.8)
30	42.8 (24.5)	0.8 (0.7)		234 (49)			
31	43.6 (31.1)	0.5 (0.6)		254 (84)			
32	35.1 (30.5)	0.8 (1.0)		232 (47)			
33	29.7 (32.6)	0.7 (1.1)		280 (30)			
34	26.2 (29.6)	0.7 (1.4)	2.3 (2.4)	228 (24)		1108 (157)	5.6 (0.8)
35	19.2 (20.9)	0.6 (0.9)		330 (28)			
36	25.8 (22.3)	0.4 (0.6)		269 (37)			
37	22.3 (19.8)	0.4 (0.5)		337 (37)			
38	16.5 (15.9)	0.3 (0.4)		234 (31)			
39	18.2 (18.0)	0.2 (0.3)	2.1 (1.0)	243 (16)		859 (108)	5.7 (0.7)
40	18.1 (18.4)	0.3 (0.2)		207 (18)			
41	19.4 (19.7)	0.1 (0.2)		264 (34)			
42	15.5 (15.6)	0.1 (0.2)		259 (19)			
43	19.5 (20.1)	0.1 (0.2)		249 (29)			
44	17.0 (14.4)	0.3 (0.6)	2.0 (1.6)	191 (38)		782 (188)	5.4 (0.8)
45	12.9 (8.7)	0.2 (0.5)		159 (39)			
46	12.7 (9.3)	0.2 (0.4)	1.5 (0.5)	170 (34)		676 (124)	6.0 (0.7)
47	12.0 (10.6)	0.2 (0.2)		160 (20)			

*Standard Deviation

TABLE A-38. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
13	4.3 (2.2)*	0.1 (0.1)		142 (38)	
15	4.6 (2.0)	0.1 (0.2)	1.4 (0.1)	97 (63)	32 (14)
17	6.3 (2.5)	0.1 (0.0)		95 (51)	
19	6.5 (4.1)	0.1 (0.1)		98 (49)	
20	6.2 (3.3)	0.1 (0.1)		80 (48)	
21	6.8 (4.0)	0.4 (0.4)	1.7 (1.5)	83 (66)	28 (17)
22	7.8 (3.7)	0.2 (0.3)		68 (40)	
23	9.3 (4.5)	0.2 (0.3)		93 (55)	
24	10.6 (3.6)	0.1 (0.3)		67 (50)	
25	12.3 (5.5)	0.1 (0.2)		70 (38)	
26	14.7 (5.1)	0.3 (0.3)	1.9 (0.9)	71 (34)	25 (11)
27	14.5 (3.6)	0.1 (0.1)		75 (26)	
28	13.3 (4.3)	0.2 (0.3)		84 (34)	
29	12.0 (5.4)	0.5 (0.8)		99 (40)	
30	14.2 (5.8)	0.1 (0.1)		121 (55)	
31	11.6 (4.4)	0.2 (0.3)	2.2 (1.0)	124 (59)	20 (7)
32	11.9 (3.9)	0.1 (0.1)		122 (55)	
33	12.4 (4.1)	0.1 (0.1)		149 (57)	
34	7.4 (5.0)	0.1 (0.1)		121 (61)	
35	7.7 (5.3)	0.1 (0.1)		187 (56)	
36	8.4 (5.3)	0.1 (0.2)	1.7 (1.2)	188 (52)	47 (31)
37	8.6 (5.2)	0.1 (0.1)		192 (56)	
38	7.4 (5.1)	0.1 (0.1)		170 (52)	
39	5.2 (3.0)	0.1 (0.1)		175 (52)	
40	7.7 (5.0)	0.1 (0.1)		154 (63)	
41	7.0 (4.0)	0.1 (0.1)	1.2 (0.6)	146 (42)	26 (10)
42	7.2 (3.6)	ND**		181 (104)	
43	6.2 (4.1)	ND		209 (137)	
44	5.1 (2.7)	ND		192 (103)	
45	4.0 (2.4)	0.1 (0.1)		195 (98)	
46	4.3 (1.4)	ND	1.0 (0.6)	180 (22)	39 (43)
47	4.0 (2.0)	ND	0.7 (0.3)	148 (32)	

*Standard Deviation

**Not Detectable

TABLE A-39. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN RYE IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
			ppm		
13	6.5 (4.9)*	0.1 (0.1)		128 (50)	
15	8.3 (3.5)	0.3 (0.3)	2.2 (1.2)	57 (46)	42 (19)
17	7.9 (3.9)	0.1 (0.1)		70 (55)	
19	8.7 (6.5)	0.1 (0.1)		80 (55)	
20	8.3 (5.2)	ND**		63 (47)	
21	8.4 (4.5)	0.2 (0.1)	2.2 (1.4)	64 (43)	42 (24)
22	9.8 (5.2)	0.1 (0.1)		50 (27)	
23	11.5 (5.1)	0.1 (0.1)		65 (40)	
24	14.1 (6.1)	ND		61 (47)	
25	13.7 (5.6)	0.1 (0.1)		76 (44)	
26	13.1 (5.8)	0.2 (0.2)	2.0 (0.9)	75 (45)	23 (10)
27	16.0 (6.0)	0.1 (0.3)		96 (37)	
28	12.8 (6.3)	0.2 (0.1)		97 (37)	
29	14.8 (5.2)	0.2 (0.1)		106 (29)	
30	12.3 (6.3)	0.3 (0.6)		149 (48)	
31	9.2 (3.7)	0.1 (0.1)	1.5 (1.2)	128 (39)	18 (6)
32	10.6 (4.1)	0.1 (0.1)		134 (40)	
33	8.4 (3.3)	ND		141 (42)	
34	4.6 (3.4)	0.1 (0.1)		109 (45)	
35	5.0 (2.8)	0.1 (0.1)		189 (39)	
36	4.6 (2.2)	0.1 (0.1)	1.2 (0.9)	198 (33)	33 (31)
37	5.2 (3.2)	0.1 (0.1)		187 (37)	
38	4.0 (2.4)	ND		190 (32)	
39	4.1 (4.0)	0.1 (0.1)		195 (26)	
40	3.7 (2.2)	0.1 (0.1)		164 (22)	
41	3.5 (1.4)	0.1 (0.1)	1.1 (0.5)	165 (32)	25 (9)
42	3.5 (1.4)	0.1 (0.1)		181 (41)	
43	4.7 (2.6)	ND		150 (47)	
44	4.1 (3.5)	ND		229 (157)	
45	4.8 (2.5)	0.1 (0.2)		170 (37)	
46	3.9 (1.8)	ND	0.8 (0.5)	175 (20)	26 (15)
47	4.0 (1.9)	0.1 (0.2)	1.3 (2.0)	156 (29)	

*Standard Deviation **Not Detectable

TABLE A-40. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N CORN IN RYEGRASS IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
			ppm		
13	7.0 (9.3)*	0.1 (0.1)		120 (50)	
15	7.4 (6.4)	0.1 (0.2)	2.4 (1.0)	65 (59)	31 (16)
17	7.9 (5.4)	0.3 (0.8)		58 (45)	
19	6.6 (5.2)	0.1 (0.1)		101 (127)	
20	9.1 (5.5)	0.2 (0.5)		48 (37)	
21	11.0 (5.6)	0.3 (0.2)	2.4 (1.3)	46 (32)	39 (17)
22	12.9 (6.5)	0.1 (0.1)		41 (21)	
23	16.2 (8.6)	0.1 (0.2)		70 (41)	
24	16.7 (7.9)	ND**		74 (48)	
25	16.2 (11.5)	0.1 (0.2)		85 (48)	
26	14.7 (9.7)	0.2 (0.3)	1.6 (0.8)	85 (42)	24 (9)
27	16.0 (9.3)	0.4 (1.0)		82 (33)	
28	14.7 (7.3)	0.2 (0.2)		103 (36)	
29	13.7 (7.3)	0.4 (0.6)		108 (35)	
30	12.3 (8.4)	0.2 (0.4)		151 (52)	
31	11.0 (9.1)	0.3 (0.3)	2.5 (1.9)	157 (51)	20 (8)
32	10.5 (9.1)	0.2 (0.4)		160 (52)	
33	10.7 (9.0)	0.2 (0.5)		174 (71)	
34	4.3 (6.9)	0.1 (0.2)		91 (55)	
35	4.4 (5.0)	0.3 (0.7)		174 (55)	
36	4.5 (5.5)	0.2 (0.1)	2.6 (3.4)	196 (54)	40 (26)
37	4.5 (4.7)	0.1 (0.1)		196 (43)	
38	4.0 (3.9)	0.1 (0.1)		169 (30)	
39	3.0 (5.3)	0.1 (0.1)		182 (32)	
40	4.4 (4.5)	0.1 (0.1)		150 (31)	
41	3.4 (3.0)	0.1 (0.1)	1.0 (0.7)	150 (29)	29 (14)
42	3.7 (2.6)	ND		181 (97)	
43	4.4 (5.0)	0.1 (0.1)		170 (113)	
44	3.3 (2.2)	ND		186 (102)	
45	2.0 (1.6)	ND		214 (130)	
46	2.1 (1.7)	0.1 (0.2)	1.1 (1.3)	176 (53)	28 (18)
47	1.7 (2.0)	0.1 (0.1)	1.0 (0.6)	165 (30)	

*Standard Deviation **Not Detectable

TABLE A-41. PARAMETERS MONITORED IN WELL SAMPLES FROM LOW N RYEGRASS IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
13	4.7 (7.2)*	0.1 (0.1)		129 (44)	
15	9.4 (7.4)	0.4 (0.4)	3.0 (1.0)	71 (32)	47 (15)
17	6.5 (4.7)	ND**		64 (34)	
19	3.5 (2.7)	0.1 (0.1)		88 (36)	
20	6.0 (5.0)	0.1 (0.1)		62 (40)	
21	6.9 (9.0)	0.2 (0.1)	2.7 (1.3)	52 (38)	50 (18)
22	9.6 (8.0)	0.1 (0.1)		47 (25)	
23	8.5 (6.7)	0.1 (0.1)		59 (34)	
24	8.9 (6.5)	0.1 (0.4)		43 (36)	
25	6.7 (4.4)	0.1 (0.1)		88 (40)	
26	6.0 (4.3)	0.2 (0.1)	1.7 (0.6)	98 (45)	32 (12)
27	4.0 (2.5)	0.1 (0.1)		107 (50)	
28	4.2 (3.1)	0.1 (0.1)		129 (31)	
29	4.4 (3.3)	0.2 (0.1)		144 (33)	
30	4.6 (4.4)	0.1 (0.1)		173 (53)	
31	3.6 (3.2)	0.2 (0.4)	2.4 (2.1)	166 (38)	23 (11)
32	3.5 (2.2)	0.1 (0.1)		172 (46)	
33	3.1 (1.3)	0.1 (0.1)		183 (44)	
34	1.6 (1.7)	0.1 (0.2)		106 (77)	
35	4.8 (4.5)	0.1 (0.2)		210 (58)	
36	1.6 (1.4)	0.2 (0.1)	1.4 (0.5)	197 (66)	34 (19)
37	1.5 (1.0)	0.2 (0.2)		206 (79)	
38	1.6 (1.2)	0.1 (0.1)		176 (61)	
39	3.0 (3.0)	0.1 (0.1)		179 (64)	
40	1.6 (1.2)	ND		156 (54)	
41	1.8 (1.5)	0.1 (0.1)	1.3 (0.8)	157 (56)	34 (15)
42	1.5 (1.3)	ND		192 (116)	
43	1.5 (1.2)	0.2 (0.6)		166 (34)	
44	1.6 (2.0)	0.2 (0.4)		153 (28)	
45	0.8 (0.9)	0.2 (0.5)		157 (40)	
46	0.6 (0.2)	0.1 (0.3)	1.0 (0.7)	194 (30)	28 (8)
47	0.6 (0.2)	0.2 (0.8)	1.2 (1.5)	183 (15)	

*Standard Deviation **Not Detectable

TABLE A-42. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N CORN IN RYE IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
13	7.4 (2.6)*	0.1 (0.1)		23 (23)	
15	5.2 (2.4)	0.5 (1.2)	2.7 (1.8)	22 (27)	34 (13)
17	8.4 (2.5)	0.1 (0.2)		38 (36)	
19	8.7 (2.2)	0.2 (0.1)		51 (41)	
20	7.7 (2.5)	0.1 (0.1)		26 (28)	
21	8.7 (3.5)	0.2 (0.2)	2.2 (0.9)	56 (45)	37 (12)
22	9.4 (2.3)	0.2 (0.2)		57 (50)	
23	10.8 (4.1)	0.1 (0.1)		47 (35)	
24	10.2 (3.2)	0.2 (0.4)		72 (63)	
25	10.9 (4.7)	0.2 (0.2)		82 (38)	
26	10.1 (5.4)	0.2 (0.1)	1.7 (1.3)	75 (44)	26 (14)
27	11.0 (6.8)	0.4 (0.4)		108 (56)	
28	10.6 (5.0)	0.8 (1.4)		125 (62)	
29	10.7 (4.4)	0.5 (1.2)		106 (65)	
30	10.0 (5.3)	0.3 (0.6)		164 (71)	
31	9.0 (4.4)	0.6 (1.8)	2.6 (4.1)	175 (62)	17 (7)
32	8.1 (4.6)	0.6 (1.7)		175 (58)	
33	7.9 (4.8)	0.4 (1.1)		182 (63)	
34	6.7 (4.9)	0.8 (0.1)		205 (72)	
35	4.4 (4.4)	0.4 (0.8)		211 (63)	
36	5.9 (4.8)	0.6 (0.9)	2.2 (1.3)	223 (68)	28 (12)
37	4.9 (4.2)	0.4 (0.6)		236 (71)	
38	4.0 (2.9)	0.2 (0.3)		220 (57)	
39	3.0 (3.0)	0.2 (0.4)		213 (57)	
40	5.0 (4.0)	0.1 (0.2)		210 (41)	
41	3.8 (2.2)	0.1 (0.3)	1.4 (0.5)	175 (45)	24 (8)
42	3.8 (2.0)	0.1 (0.2)		190 (43)	
43	3.5 (2.4)	0.1 (0.1)		188 (48)	
44	3.4 (2.2)	0.1 (0.1)		186 (77)	
45	3.1 (2.3)	0.1 (0.1)		190 (51)	
46	3.1 (2.2)	0.2 (0.2)	1.1 (0.5)	172 (58)	33 (28)
47	3.8 (1.4)	0.1 (0.1)	1.0 (0.4)	146 (28)	

*Standard Deviation

TABLE A-43. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N CORN IN RYE IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
13	9.8 (4.8)*	0.2 (0.2)		60 (56)	
15	7.5 (5.0)	1.0 (2.8)	3.6 (4.0)	42 (42)	34 (13)
17	10.2 (4.5)	0.2 (0.7)		54 (43)	
19	9.5 (3.6)	0.4 (1.1)		84 (44)	
20	9.5 (4.0)	0.2 (0.6)		37 (32)	
21	6.0 (2.9)	0.4 (0.3)	2.6 (1.5)	63 (50)	41 (15)
22	7.2 (3.1)	0.4 (0.6)		61 (54)	
23	6.6 (3.5)	0.5 (0.8)		85 (84)	
24	7.2 (3.7)	0.6 (0.9)		72 (60)	
25	5.7 (4.4)	1.0 (1.8)		81 (40)	
26	4.6 (3.5)	0.5 (0.7)	2.1 (0.8)	66 (33)	24 (10)
27	5.3 (4.1)	0.6 (0.9)		92 (35)	
28	4.1 (2.4)	0.7 (1.3)		114 (70)	
29	5.7 (4.2)	1.9 (2.9)		120 (69)	
30	6.9 (6.3)	0.8 (1.3)		156 (64)	
31	6.0 (4.0)	1.7 (2.8)	3.6 (4.2)	159 (71)	23 (11)
32	6.2 (4.7)	1.4 (2.5)		166 (66)	
33	6.5 (4.8)	0.4 (0.8)		168 (72)	
34	4.1 (5.1)	0.1 (0.2)		151 (77)	
35	4.1 (3.6)	0.5 (1.2)		220 (69)	
36	3.6 (3.2)	0.7 (1.0)	2.3 (1.9)	240 (59)	27 (12)
37	3.5 (2.6)	0.4 (0.4)		248 (91)	
38	3.7 (2.7)	0.3 (0.6)		214 (79)	
39	4.5 (2.0)	0.3 (0.4)		221 (93)	
40	3.4 (2.6)	0.3 (0.5)		215 (69)	
41	2.8 (2.0)	0.1 (0.2)	1.6 (1.3)	185 (91)	34 (51)
42	2.7 (1.8)	0.2 (0.5)		209 (74)	
43	2.8 (2.0)	0.5 (1.3)		220 (113)	
44	2.2 (1.8)	0.1 (0.2)		235 (95)	
45	2.2 (2.5)	0.2 (0.4)		198 (38)	
46	3.5 (2.4)	0.1 (0.1)	1.3 (1.6)	189 (78)	33 (23)
47	3.4 (2.6)	0.2 (0.4)	1.0 (0.9)	174 (61)	

*Standard Deviation

TABLE A-44. PARAMETERS MONITORED IN WELL SAMPLES FROM HIGH N RYEGRASS IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C
	ppm				
13	11.8 (9.1)*	0.4 (0.5)		70 (34)	
15	10.7 (8.4)	0.4 (0.6)	3.7 (1.8)	32 (23)	38 (13)
17	9.8 (0.2)	0.2 (0.4)		51 (29)	
19	7.0 (5.4)	0.2 (0.5)		71 (30)	
20	8.8 (5.8)	0.2 (0.6)		34 (22)	
21	4.1 (3.7)	0.2 (0.2)	2.6 (1.1)	83 (54)	40 (7)
22	7.1 (5.2)	0.1 (0.1)		70 (59)	
23	4.8 (4.0)	0.3 (0.6)		92 (58)	
24	6.4 (3.9)	0.9 (1.5)		87 (71)	
25	3.1 (4.6)	2.0 (6.3)		95 (44)	
26	2.3 (3.3)	0.8 (1.9)	2.8 (2.0)	75 (46)	32 (10)
27	2.0 (3.3)	1.0 (1.6)		109 (37)	
28	2.2 (3.3)	2.2 (3.7)		168 (40)	
29	2.7 (3.7)	2.2 (3.6)		134 (63)	
30	1.6 (1.9)	1.3 (3.0)		207 (40)	
31	1.1 (1.4)	1.8 (2.7)	3.8 (3.5)	216 (28)	29 (9)
32	2.8 (2.9)	1.4 (2.4)		220 (31)	
33	2.5 (2.5)	1.1 (1.8)		241 (62)	
34	1.3 (2.2)	0.2 (0.4)		125 (79)	
35	1.6 (2.1)	0.9 (1.5)		165 (54)	
36	1.4 (2.2)	1.0 (1.0)	3.6 (2.4)	191 (64)	52 (44)
37	1.2 (1.2)	0.6 (0.5)		189 (62)	
38	1.0 (0.9)	0.5 (0.4)		121 (64)	
39	2.5 (3.1)	0.6 (0.7)		158 (62)	
40	1.1 (1.0)	0.3 (0.6)		152 (46)	
41	1.1 (1.0)	0.2 (0.2)	1.5 (0.6)	112 (73)	29 (6)
42	0.8 (0.6)	0.1 (0.2)		159 (68)	
43	0.6 (0.3)	0.3 (0.1)		159 (98)	
44	0.6 (0.2)	0.4 (1.0)		180 (90)	
45	0.7 (0.5)	0.2 (0.4)		201 (53)	
46	0.8 (0.5)	0.2 (0.2)	1.2 (0.4)	179 (100)	25 (6)
47	0.8 (0.4)	0.1 (0.1)	0.9 (0.4)	123 (76)	

*Standard Deviation

TABLE A-45. PARAMETERS MONITORED IN WELL SAMPLES FROM 7 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1978

Week	NO_3-N	NH_4-N	Kjeldahl N	Cl	Total C	Spec. Cond.	pH
	ppm					umhos/cm	
13	9.2 (4.2)*	0.1 (0.1)		20 (24)			
15	7.8 (2.7)	0.2 (0.3)	2.5 (0.1)	20 (24)	33 (13)	201 (99)	5.9 (0.9)
17	10.5 (3.4)	0.1 (0.1)		31 (29)			
19	10.3 (2.8)	0.1 (0.1)		54 (35)			
20	9.1 (3.9)	0.1 (0.2)		16 (13)			
21	9.2 (4.2)	0.5 (0.7)	2.8 (1.8)	56 (70)	47 (24)	294 (208)	6.0 (0.7)
22	9.4 (3.7)	0.8 (1.9)		56 (76)			
23	9.9 (4.7)	0.7 (2.5)		72 (82)			
24	10.6 (4.8)	0.6 (2.2)		57 (64)			
25	12.0 (7.2)	0.5 (0.8)		83 (40)			
26	10.3 (6.6)	0.2 (0.4)	1.5 (0.9)	73 (45)	23 (8)	437 (178)	5.9 (0.6)
27	12.8 (9.4)	0.3 (0.4)		107 (38)			
28	12.1 (7.1)	1.1 (2.8)		147 (41)			
29	12.8 (7.4)	1.0 (2.6)		133 (34)			
30	9.4 (6.9)	0.6 (1.2)		184 (44)			
31	11.0 (7.0)	1.3 (2.7)	1.4 (1.3)	184 (45)	17 (6)	855 (162)	5.6 (0.4)
32	10.4 (6.3)	0.1 (2.6)		190 (42)			
33	8.6 (6.8)	0.3 (0.5)		204 (51)			
34	7.3 (5.1)	0.2 (0.3)		209 (62)			
35	6.5 (4.9)	0.3 (0.6)		239 (58)			
36	5.4 (4.3)	0.6 (0.8)	6.0 (6.5)	251 (61)	74 (59)	942 (130)	5.7 (0.9)
37	5.5 (4.0)	0.4 (0.5)		242 (57)			
38	4.0 (2.4)	0.2 (0.3)		211 (81)			
39	2.9 (2.8)	0.3 (0.3)		210 (74)			
40	4.0 (3.0)	0.1 (0.2)		205 (59)			
41	3.8 (2.0)	0.1 (0.1)	1.9 (1.6)	146 (59)	33 (13)	766 (168)	6.1 (0.6)
42	3.8 (2.3)	ND**		178 (55)			
43	3.8 (1.9)	0.2 (0.2)		176 (67)			
44	3.4 (1.8)	ND		176 (50)			
45	3.4 (2.3)	0.1 (0.1)		191 (71)			
46	4.0 (1.3)	0.1 (0.1)	1.1 (0.6)	183 (62)	27 (10)	703 (147)	6.1 (0.5)
47	5.2 (3.8)	0.2 (0.2)	1.6 (1.1)	141 (53)		751 (156)	6.0 (0.5)

*Standard Deviation **Not Detectable

TABLE A-46. PARAMETERS MONITORED IN WELL SAMPLES FROM 22 T/Ha SLUDGE APPLIED TO HIGH N CORN IN 1978

Week	NO_3-N		NH_4-N		Kjeldahl N		Cl		Total C		Spec. Cond.		pH	
	-----------	-----------	-----------	ppm	-----------	-----------	-----------	-----------	-----------	-----------	umhos/cm			
13	10.5	(3.3)*	0.2	(0.2)			45	(46)						
15	7.8	(4.6)	0.1	(0.1)	2.8	(2.5)	35	(40)	32	(11)	270	(157)	5.9	(1.0)
17	10.6	(4.5)	ND**				36	(30)						
19	11.6	(4.0)	0.2	(0.2)			60	(40)						
20	10.3	(3.2)	0.1	(0.1)			35	(28)						
21	11.1	(5.4)	0.4	(0.4)	2.9	(1.1)	72	(56)	42	(15)	409	(195)	6.0	(0.7)
22	11.6	(5.2)	0.4	(0.6)			57	(50)						
23	12.2	(5.6)	0.2	(0.2)			66	(56)						
24	12.0	(5.2)	0.4	(0.6)			58	(55)						
25	15.1	(7.4)	0.4	(0.7)			85	(40)						
26	15.5	(7.5)	0.2	(0.3)	1.3	(0.9)	74	(40)	22	(8)	464	(161)	5.9	(0.6)
27	15.5	(9.3)	0.5	(0.9)			118	(55)						
28	14.4	(8.0)	1.6	(3.1)			139	(53)						
29	16.9	(10.3)	0.7	(1.0)			123	(60)						
30	14.4	(6.9)	0.3	(0.5)			169	(64)						
31	12.4	(7.1)	0.4	(0.8)	1.6	(1.5)	163	(56)	24	(15)	861	(260)	5.8	(0.8)
32	12.7	(7.4)	0.6	(0.9)			150	(53)						
33	11.9	(7.0)	0.2	(0.4)			162	(63)						
34	6.0	(5.2)	0.1	(0.2)			169	(66)						
35	6.8	(5.3)	0.3	(0.4)			208	(49)						
36	6.3	(5.4)	0.4	(0.6)	3.6	(2.1)	231	(57)	42	(19)	894	(145)	5.7	(0.8)
37	7.0	(6.3)	0.3	(0.5)			243	(55)						
38	4.5	(4.5)	0.2	(0.2)			198	(75)						
39	5.5	(4.5)	0.2	(0.2)			209	(68)						
40	5.1	(5.6)	ND				195	(70)						
41	4.2	(3.9)	0.2	(0.5)	2.0	(1.0)	148	(45)	31	(11)	786	(125)	6.0	(0.8)
42	4.3	(4.7)	0.9	(3.1)			206	(74)						
43	5.0	(5.8)	0.9	(2.9)			194	(76)						
44	4.6	(4.9)	0.4	(1.3)			197	(57)						
45	4.7	(4.5)	0.4	(1.1)			199	(51)						
46	5.2	(3.2)	0.1	(0.1)	1.1	(0.7)	197	(60)	47	(42)	765	(145)	6.1	(0.7)
47	5.0	(4.6)	0.2	(0.2)	1.4	(1.2)	156	(53)			823	(132)	6.0	(0.8)

*Standard Deviation **Not Detectable

TABLE A-47. NUTRIENT CONTENT OF PLANT TISSUE FROM THE NITROGEN STRIPPING EXPERIMENT IN 1976

Treatment	Week	Total K	Total P	Total N
		ppm		
Low N Corn	27	37700 (3300)	2500 (100)	24500 (2200)*
	32	27800 (5800)	2800 (400)	6500 (700)
	35	26200 (2200)	700 (100)	6300 (800)
Low N Ryegrass	27	46100 (6900)	3600 (400)	24800 (3600)
	32	38400 (1900)	3700 (400)	20900 (3600)
	35	15100 (1800)	2500 (400)	11600 (2300)
Low N Corn in Ryegrass	27	42400 (5400)	3600 (600)	13100 (1200)
	32	25800 (2800)	2900 (600)	15200 (1600)
	35	11800 (800)	1100 (300)	6600 (200)
Ryegrass	27	28100 (4700)	2800 (900)	16300 (1300)
	32	19800 (2300)	2400 (200)	19700 (5400)
	35	11800 (800)	1100 (300)	6600 (200)

*Standard Deviation

TABLE A-48. NUTRIENT CONTENT OF PLANT TISSUE SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1977

Treatment	Week	Ca	Mg	K	Total P	Total N
		ppm				
Low N Corn	22	3197 (199)*	2576 (105)	25860 (2040)	2324 (333)	20176 (2172)
	31	5548 (160)	4412 (641)	45580 (1880)	3242 (418)	31600 (2929)
	40	2888 (511)	5451 (490)	13982 (2900)	533 (142)	6350 (1050)
Low N Corn in Rye	22	6567 (4057)	2761 (459)	23080 (3530)	2805 (466)	21188 (2995)
	31	6190 (1563)	4619 (1132)	48250 (970)	3611 (500)	28764 (2780)
	40	3023 (1118)	6062 (541)	12416 (2917)	680 (208)	7184 (1249)
Low N Corn in Ryegrass	22	9719 (7864)	3485 (800)	64390 (81300)	3127 (516)	23695 (3714)
	31	5088 (167)	3604 (455)	44260 (2950)	3513 (194)	26036 (1227)
	40	3308 (891)	4830 (1539)	8764 (2652)	838 (437)	6952 (2570)
Low N Ryegrass Hay	22	21741 (6857)	5647 (3599)	22871 (9492)	4033 (1024)	22849 (5945)
High N Corn	22	5028 (635)	2469 (430)	30190 (5390)	2280 (407)	22282 (2004)
	31	6606 (1081)	3579 (316)	46220 (1080)	3429 (530)	30141 (458)
	40	4110 (577)	2196 (141)	14571 (3086)	1671 (2583)	5860 (3994)
High N Corn in Rye	22	4671 (917)	2165 (760)	21670 (7470)	2367 (378)	23443 (11180)
	31	7567 (827)	4104 (408)	46340 (2440)	3054 (563)	28926 (1915)
	40	3713 (379)	2149 (136)	13577 (2628)	702 (117)	87496 (7434)
High N Ryegrass Hay	22	29495 (6821)	9968 (1924)	24976 (5823)	4482 (1058)	32410 (5204)
7 T/Ha Sludge Applied to High N Corn	22	5068 (283)	2596 (340)	28360 (4000)	2848 (267)	22120 (1529)
	31	8444 (1333)	3684 (921)	45750 (8400)	3938 (1402)	26252 (9399)
	40	4591 (368)	2189 (162)	14241 (1972)	755 (160)	9071 (536)
22 T/Ha Sludge Applied to High N Corn	22	6336 (1366)	3667 (582)	26950 (12570)	3454 (1011)	21148 (4162)
	31	8888 (681)	3994 (425)	41870 (3630)	4504 (71)	32410 (2292)
	40	4916 (467)	2152 (263)	13909 (1736)	843 (112)	9071 (659)

*Standard Deviation

TABLE A-49. NUTRIENT CONTENT OF PLANT TISSUE SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1978

Treatment	Week	Ca	Mg	K	Total P	Total N
		ppm				
Low N Corn	27	3380 (434)*	3055 (240)	58484 (4216)	2323 (295)	20391 (2285)
	30	2241 (302)	2838 (716)	15324 (4372)	1693 (298)	12721 (2325)
	39	896 (271)	1486 (188)	6501 (622)	1604 (281)	9350 (879)
Low N Corn in Rye	27	3999 (501)	3269 (314)	53016 (8856)	3269 (627)	20418 (2626)
	30	4314 (875)	3379 (618)	17635 (3169)	2677 (402)	15422 (2243)
	39	910 (189)	1437 (112)	6200 (737)	2037 (449)	9643 (830)
	46	5812 (119)	2442 (257)	11207 (3980)	2124 (303)	18633 (1286)
Low N Corn in Ryegrass	27	4931 (1112)	3260 (681)	59454 (9862)	3581 (548)	22984 (4630)
	30	4085 (1138)	2984 (727)	20768 (3330)	2738 (406)	17960 (3070)
	39	1022 (253)	1568 (234)	6820 (844)	2015 (187)	8594 (863)
Low N Ryegrass Hay	23	4410 (693)	1747 (362)	55937 (5037)	2861 (477)	22282 (2687)
	30	6196 (1198)	3392 (552)	20922 (4971)	3550 (858)	20634 (2285)
	36	6701 (656)	3554 (379)	26179 (3706)	3302 (773)	24307 (2296)
	46	6328 (503)	2368 (349)	12505 (3639)	2578 (578)	18880 (3550)
High N Corn	27	3591 (574)	2230 (462)	49185 (13699)	1772 (340)	20526 (2427)
	30	2425 (398)	1932 (255)	18411 (4528)	1795 (280)	13572 (4261)
	39	963 (297)	1342 (178)	8982 (985)	1906 (266)	9469 (1302)
High N Corn in Rye	27	6515 (2438)	2279 (504)	40537 (6125)	1973 (296)	18717 (2684)
	30	4821 (1785)	2526 (439)	16646 (4873)	2085 (541)	17171 (3851)
	39	1067 (264)	1461 (220)	8595 (1002)	1654 (179)	9946 (1139)
High N Ryegrass Hay	23	5348 (1707)	1636 (169)	61816 (8221)	2601 (472)	18420 (3325)
	30	5711 (828)	2262 (398)	15544 (4236)	2531 (588)	19755 (3747)
	36	8208 (1198)	2699 (446)	12919 (5834)	2350 (666)	25341 (3118)
	46	6409 (736)	1570 (97)	8410 (2071)	1605 (210)	15372 (1590)
7 T/Ha Sludge Applied to High N Corn	27	3271 (395)	1319 (798)	51505 (10705)	1990 (335)	19446 (2812)
	30	2527 (535)	1912 (229)	16316 (3825)	1755 (325)	13969 (2506)
	39	869 (124)	1316 (172)	8514 (912)	1847 (236)	9807 (1111)
22 T/Ha Sludge Applied to High N Corn	27	3584 (448)	2192 (442)	43453 (15232)	2321 (408)	19365 (3337)
	30	2796 (1581)	1909 (347)	16272 (4467)	2147 (400)	14466 (5044)
	39	993 (246)	1330 (204)	8276 (771)	1887 (302)	10205 (1260)

*Standard Deviation

TABLE A-50. NUTRIENT CONTENT OF GRAIN SAMPLES FROM NITROGEN STRIPPING EXPERIMENT IN 1976

Treatment	Week	Total K	Total P	Total N
		ppm	ppm	ppm
Low N Corn	35	40000 (400)	2800 (200)	10300 (1300)*
	45	41100 (300)	2900 (100)	11900 (1000)
Low N Corn in Ryegrass	35	38700 (100)	2900 (200)	10900 (1600)
	45	40800 (400)	3000 (200)	11800 (1500)
Low N Corn in Rye	45	45600 (100)	3400 (200)	10100 (1000)

*Standard Deviation

TABLE A-51. NUTRIENT CONTENT OF GRAIN SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1977

Treatment	Ca	Mg	K	Total P	Total N
	ppm				
Low N Corn	162 (54)*	1127 (99)	2763 (409)	2271 (578)	13700 (1795)
Low N Corn in Rye	136 (24)	1117 (165)	2832 (719)	2239 (531)	13365 (1071)
Low N Corn in Ryegrass	169 (30)	1243 (200)	3420 (767)	2523 (315)	13446 (580)
High N Corn	146 (38)	1271 (216)	3243 (817)	1964 (534)	15412 (1202)
High N Corn in Rye	138 (40)	1147 (313)	3184 (1465)	2183 (635)	14378 (1144)
7 T/Ha Sludge Applied to High N Corn	129 (29)	1215 (140)	3028 (208)	1999 (718)	15412 (889)
22 T/Ha Sludge Applied to High N Corn	144 (36)	1250 (253)	3037 (800)	2127 (498)	16054 (841)

*Standard Deviation

TABLE A-52. NUTRIENT CONTENT OF GRAIN SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1978

Treatment	Ca	Mg	K	Total P	Total N
	ppm				
Low N Corn	42 (10)*	1133 (110)	3025 (285)	2186 (511)	13816 (1473)
Low N Corn in Rye	53 (22)	1288 (133)	3531 (485)	3043 (687)	13938 (1086)
Low N Corn in Ryegrass	47 (18)	1337 (125)	3727 (332)	3136 (576)	13430 (1474)
High N Corn	48 (10)	1161 (194)	3044 (441)	2560 (461)	13891 (958)
High N Corn in Rye	49 (12)	1212 (80)	3291 (344)	2759 (307)	13714 (891)
7 T/Ha Sludge Applied to High N Corn	77 (50)	1284 (200)	3436 (456)	3052 (594)	14752 (870)
22 T/Ha Sludge Applied to High N Corn	55 (10)	1189 (129)	3261 (451)	2882 (513)	13395 (1673)

*Standard Deviation

TABLE A-53. HEAVY METAL CONTENT OF PLANT TISSUE SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1977

Treatment	Week	Fe	Mn	Cu	Zn
		ppm			
Low N Corn	22	137 (42)*	44 (9)	8 (2)	62 (13)
	31	110 (14)	43 (9)	6 (2)	75 (9)
	40	74 (8)	44 (7)	8 (1)	41 (11)
Low N Corn in Rye	22	128 (48)	39 (20)	8 (3)	51 (14)
	31	184 (138)	33 (10)	8 (2)	98 (58)
	40	66 (8)	24 (10)	6 (3)	29 (7)
Low N Corn in Ryegrass	22	145 (20)	42 (21)	8 (3)	52 (4)
	31	105 (22)	23 (2)	6 (1)	62 (6)
	40	66 (16)	27 (6)	8 (5)	34 (10)
Low N Ryegrass Hay	22	225 (104)	91 (44)	8 (4)	78 (43)
High N Corn	22	199 (78)	89 (45)	7 (2)	71 (26)
	31	215 (43)	82 (8)	12 (1)	96 (8)
	40	129 (52)	90 (25)	11 (3)	52 (12)
High N Corn in Rye	22	234 (141)	78 (36)	7 (2)	54 (17)
	31	180 (31)	61 (16)	9 (2)	81 (18)
	40	113 (36)	65 (12)	12 (4)	44 (9)
High N Ryegrass Hay	22	327 (120)	159 (58)	11 (3)	85 (31)
7 T/Ha Sludge Applied to High N Corn	22	162 (26)	84 (9)	8 (1)	86 (11)
	31	463 (443)	101 (25)	19 (15)	130 (105)
	40	104 (23)	77 (15)	12 (2)	60 (12)
22 T/Ha Sludge Applied	22	225 (105)	88 (14)	10 (3)	124 (17)
	31	180 (15)	95 (28)	15 (1)	96 (7)
	40	110 (29)	67 (15)	12 (4)	94 (33)

*Standard Deviation

TABLE A-54. HEAVY METAL CONTENT OF PLANT TISSUE SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1978

Treatment	Week	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni
		ppm							
Low N Corn	27	68 (38)*	27 (10)	4 (1)	40 (7)				
	30	33 (7)	18 (6)	3 (1)	31 (4)	15 (2)	ND**	3 (2)	ND
	39	24 (6)	ND	3 (0)	24 (3)	12 (1)	ND	ND	ND
Low N Corn in Rye	27	66 (29)	20 (8)	4 (1)	40 (5)				
	30	145 (105)	24 (11)	3 (1)	35 (6)	13 (3)	3 (2)	4 (2)	ND
	39	20 (3)	ND	3 (1)	24 (3)	13 (2)	3 (0)	ND	ND
Low N Corn in Ryegrass	27	80 (25)	32 (13)	5 (1)	48 (6)				
	30	72 (32)	33 (19)	5 (5)	38 (6)	14 (2)	ND	4 (5)	ND
	39	28 (13)	ND	3 (1)	28 (5)	12 (2)	ND	ND	ND
Low N Ryegrass Hay	23	52 (13)	28 (7)	7 (4)	28 (3)				
	30	156 (138)	45 (14)	3 (2)	38 (8)	14 (3)	ND	6 (5)	3 (1)
	36	128 (33)	61 (25)	7 (1)	33 (7)	6 (1)	4 (3)	ND	ND
	46	297 (95)	80 (23)	6 (1)	37 (7)	8 (2)	ND	ND	ND
High N Corn	27	136 (61)	38 (9)	2 (1)	50 (10)				
	30	82 (25)	36 (7)	3 (2)	44 (10)	16 (3)	ND	ND	4 (2)
	39	31 (6)	ND	ND	28 (4)	13 (1)	ND	ND	ND
High N Corn in Rye	27	116 (56)	60 (34)	4 (2)	42 (7)				
	30	141 (107)	52 (36)	5 (2)	48 (10)	17 (2)	ND	ND	5 (2)
	39	26 (9)	ND	ND	26 (5)	12 (2)	ND	ND	ND
High N Ryegrass Hay	23	86 (18)	59 (34)	8 (2)	30 (3)				
	30	108 (63)	77 (24)	5 (2)	52 (3)	20 (2)	ND	3 (1)	5 (2)
	36	435 (451)	95 (32)	4 (1)	33 (7)	6 (2)	ND	ND	ND
	46	670 (388)	123 (50)	7 (1)	29 (6)	8 (2)	ND	ND	ND
7 T/Ha Sludge Applied to High N Corn	27	112 (71)	34 (10)	4 (2)	60 (8)				
	30	133 (96)	30 (9)	5 (3)	47 (8)	18 (4)	ND	ND	4 (1)
	39	27 (6)	ND	ND	30 (4)	13 (1)	ND	ND	ND
22 T/Ha Sludge Applied to High N Corn	27	119 (51)	26 (10)	4 (2)	65 (12)				
	30	134 (102)	22 (7)	4 (3)	54 (9)	16 (2)	ND	ND	4 (2)
	39	29 (5)	ND	ND	28 (5)	13 (1)	ND	ND	ND

*Standard Deviation **Not Detectable

TABLE A-55. HEAVY METAL CONTENT OF GRAIN SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1977

Treatment	Fe	Mn	Cu	Zn
	----------	----------	ppm ----------	----------
Low N Corn	25 (7)*	4 (1)	ND**	28 (12)
Low N Corn in Rye	19 (17)	4 (1)	ND	21 (3)
Low N Corn in Ryegrass	30 (20)	5 (1)	ND	23 (4)
High N Corn	44 (26)	6 (2)	4 (1)	28 (6)
High N Corn in Rye	31 (12)	5 (2)	4 (2)	25 (9)
7 T/Ha Sludge Applied to High N Corn	31 (10)	6 (1)	4 (2)	27 (3)
22 T/Ha Sludge Applied	38 (18)	6 (1)	3 (2)	30 (9)

*Standard Deviation **Not Detectable

TABLE A-56. HEAVY METAL CONTENT OF GRAIN SAMPLES FROM THE NITROGEN STRIPPING EXPERIMENT IN 1978

Treatment	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni
	ppm							
Low N Corn	45 (15)*	6 (3)	ND**	19 (4)	8 (3)	ND	ND	3 (1)
Low N Corn in Rye	34 (10)	4 (1)	ND	21 (4)	10 (2)	ND	ND	ND
Low N Corn in Ryegrass	37 (13)	6 (1)	ND	23 (2)	8 (2)	ND	ND	ND
High N Corn	50 (19)	15 (11)	ND	26 (8)	7 (1)	ND	ND	ND
High N Corn in Rye	49 (12)	11 (5)	ND	26 (3)	8 (1)	ND	ND	ND
7 T/Ha Sludge Applied to High N Corn	57 (20)	9 (4)	3 (1)	28 (6)	8 (1)	ND	ND	ND
22 T/Ha Sludge Applied to High N Corn	54 (32)	7 (4)	ND	31 (6)	8 (1)	ND	ND	ND

*Standard Deviation **Not Detectable

APPENDIX B

DATA FOR METAL CONTAMINATED SLUDGE EXPERIMENTS

TABLE B-1. DTPA EXTRACTED HEAVY METALS FROM SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1976

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
		ppm								
		No Sludge Applied								
24	0-15	109 (38)*	4.6 (2.4)	0.4 (0.3)	4.8 (1.7)	0.2 (0.2)	5.3 (2.4)	0.2 (0.2)	0.4 (0.2)	ND**
	15-30	72 (23)	1.6 (1.0)	0.3 (0.1)	1.5 (0.8)	0.2 (0.3)	2.1 (0.8)	ND	0.7 (0.6)	ND
28	0-15	137 (36)	0.6 (0.6)	0.3 (0.2)	4.4 (1.1)	0.2 (0.3)	2.3 (0.9)	0.2 (0.3)	2.9 (1.7)	ND
	15-30	77 (18)	0.9 (0.5)	0.23 (0.15)	1.13 (0.65)	1.2 (1.2)	0.9 (0.9)	0.15 (0.30)	1.7 (1.2)	ND
32	0-15	195 (44)	1.8 (0.6)	0.6 (0.7)	2.9 (1.2)	0.1 (0.1)	2.1 (0.7)	0.1 (0.1)	0.1 (0.1)	ND
	15-30	136 (14)	0.8 (0.4)	.03 (0.05)	1.0 (0.6)	0.1 (0.1)	0.2 (0.4)	ND	0.2 (0.2)	ND
45	0-15	158 (42)	1.4 (0.4)	0.1 (0.1)	2.7 (0.7)	1.40 (0.8)	4.00 (1.4)	0.10 (.08)	0.9 (0.5)	ND
	15-30	105 (20)	0.8 (0.3)	ND	1.6 (1.4)	0.90 (0.2)	2.50 (0.3)	0.12 (.1)	0.68 (0.29)	ND
		11 T/Ha Sludge Applied								
24	0-15	99 (41)	2.8 (0.8)	4.7 (1.9)	15.2 (5.1)	0.2 (0.3)	4.4 (1.0)	0.2 (0.1)	4.4 (1.1)	ND
	15-30	74 (34)	1.8 (1.3)	0.3 (0.1)	1.9 (1.0)	0.2 (0.3)	2.5 (0.9)	ND	0.4 (0.3)	ND
28	0-15	152 (80)	0.4 (0.5)	6.3 (4.1)	19.5 (8.1)	0.6 (0.8)	2.5 (0.4)	0.1 (0.1)	4.98 (2.7)	ND
	15-30	112 (88)	0.55 (0.48)	0.28 (0.17)	1.48 (1.05)	ND	1.5 (0.5)	ND	0.2 (0.5)	ND
32	0-15	186 (57)	2.4 (0.8)	4.5 (0.9)	13.8 (1.2)	0.1 (0.1)	2.6 (0.7)	0.1 (0)	1.9 (0.7)	ND
	15-30	162 (48)	2.2 (1.4)	0.2 (0.3)	1.9 (0.4)	ND	0.9 (0.8)	ND	ND	ND
45	0-15	208 (116)	1.5 (0.9)	8.8 (5.6)	14.6 (7.2)	1.35 (0.6)	4.15 (0.7)	0.20 (.08)	3.23 (2.4)	ND
	15-30	141 (43)	1.4 (0.7)	0.4 (0.3)	2.4 (1.6)	1.15 (0.56)	2.43 (0.6)	0.02 (.05)	1.15 (0.37)	ND

(Continued)

*Standard Deviation **Not Detectable

TABLE B-1. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
		ppm								
		22 T/Ha Sludge Applied								
24	0-15	101 (41)*	3.2 (1.1)	7.8 (1.3)	23.8 (2.5)	0.2 (0.3)	4.9 (0.8)	0.3 (0.2)	7.8 (3.0)	ND**
	15-30	58 (22)	1.3 (0.4)	0.3 (0.1)	2.0 (0.3)	0.1 (0.1)	1.6 (0.9)	ND	0.6 (0.2)	ND
28	0-15	168 (58)	0.7 (0.6)	9.6 (2.6)	32.0 (6.3)	0.6 (0.7)	2.4 (1.7)	0.8 (0.8)	8.96 (0.5)	ND
	15-30	105 (50)	0.5 (0.9)	0.13 (0.1)	2.25 (1.76)	1.05 (1.3)	1.1 (0.5)	0.13 (0.15)	1.1 (0.4)	ND
32	0-15	190 (45)	2.9 (1.8)	19.3 (12.9)	20.0 (5.3)	0.1 (0.1)	5.1 (2.3)	0.2 (0.1)	4.6 (2.3)	ND
	15-30	135 (34)	1.3 (0.9)	0.2 (0.3)	1.6 (0.4)	ND	0.3 (0.4)	ND	ND	ND
45	0-15	149 (46)	1.3 (0.4)	15.0 (8.4)	27.7 (4.4)	1.83 (0.8)	5.43 (0.7)	0.25 (0.13)	9.15 (4.6)	ND
	15-30	106 (46)	1.2 (0.6)	0.3 (0.2)	2.5 (0.5)	0.90 (0.47)	2.55 (0.2)	0.08 (0.1)	1.15 (0.52)	ND
		54 T/Ha Sludge Applied								
24	0-15	91 (20)	3.9 (2.8)	14.2 (5.7)	23.2 (4.4)	0.2 (0.3)	5.4 (2.5)	0.3 (0.1)	10.6 (3.0)	ND
	15-30	50 (12)	1.7 (1.1)	0.6 (0.6)	2.7 (1.3)	ND	1.7 (0.7)	ND	0.7 (0.3)	ND
28	0-15	141 (85)	2.0 (1.8)	13.8 (2.9)	54.5 (19.5)	0.4 (0.8)	2.4 (0.4)	0.1 (0.1)	10.15 (7.7)	ND
	15-30	65 (30)	1.0 (1.51)	0.23 (0.15)	1.30 (0.42)	0.9 (0.7)	1.2 (0.8)	0.08 (0.15)	0.9 (0.7)	ND
32	0-15	170 (47)	2.3 (0.7)	21.9 (3.9)	23.1 (9.6)	0.1 (0.1)	3.2 (0.9)	0.2 (0.1)	7.6 (1.2)	ND
	15-30	111 (55)	1.6 (0.7)	0.6 (0.4)	2.2 (1.0)	ND	0.1 (0.2)	ND	ND	ND
45	0-15	128 (38)	1.3 (0.3)	19.7 (6.2)	55.9 (13.4)	1.63 (0.9)	4.63 (0.9)	0.38 (0.13)	12.3 (3.2)	ND
	15-30	72 (15)	1.3 (1.1)	1.1 (0.5)	3.5 (0.7)	1.20 (0.56)	1.93 (0.5)	0.16 (0.09)	1.25 (0.76)	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-1. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		99 T/Ha Sludge Applied								
24	0-15	82 (20)*	5.1 (2.0)	17.0 (1.4)	43.8 (14.9)	0.2 (0.3)	8.3 (2.1)	0.4 (0.2)	18.2 (5.0)	ND**
	15-30	72 (56)	2.8 (1.1)	1.0 (0.6)	4.8 (1.6)	0.1 (0.1)	1.8 (0.4)	ND	0.9 (0.2)	ND
28	0-15	148 (48)	3.1 (1.7)	34.1 (5.9)	70.9 (9.6)	0.5 (0.4)	6.2 (2.4)	0.15 (0.8)	39.53 (15.8)	ND
	15-30	90 (60)	0.75 (1.08)	0.48 (0.22)	2.75 (0.73)	0.2 (0.3)	1.8 (0.7)	0.43 (0.85)	0.2 (0.4)	ND
32	0-15	172 (64)	3.3 (1.8)	38.6 (12.2)	79.7 (4.1)	0.1 (0.1)	5.6 (1.9)	0.7 (0.4)	13.9 (7.4)	ND
	15-30	146 (52)	2.0 (0.7)	1.05 (1.2)	4.2 (3.1)	0.1 (0.1)	0.5 (0.6)	ND	0.3 (0.6)	ND
45	0-15	184 (25)	1.6 (0.6)	31.7 (9.9)	99.9 (50.2)	1.38 (0.8)	5.50 (1.5)	0.38 (0.29)	22.6 (3.6)	ND
	15-30	129 (58)	1.7 (0.8)	7.7 (6.0)	12.6 (4.3)	1.03 (0.52)	2.55 (1.00)	0.28 (0.17)	5.2 (3.4)	ND

*Standard Deviation **Not Detectable

TABLE B-2. DTPA EXTRACTED HEAVY METALS FROM SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1977

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	-----	-----	-----	-----	ppm	-----	-----	-----	-----
					No Sludge Applied					
21	0-15	152 (66)*	4.3 (1.4)	0.8 (0.9)	5.0 (3.0)	ND**	2.0 (0.7)	0.2 (0.0)	0.3 (0.5)	ND
21	15-30	84 (28)	1.6 (1.0)	0.2 (0.1)	2.0 (0.1)	ND	0.3 (0.2)	ND	ND	ND
26	0-15	142 (65)	5.1 (2.5)	2.4 (1.2)	10.2 (1.6)	0.2 (0.2)	4.5 (4.1)	0.7 (0.9)	1.7 (0.5)	ND
26	15-30	84 (18)	1.4 (0.5)	0.7 (0.6)	1.2 (1.0)	ND	2.8 (5.1)	ND	1.0 (0.7)	ND
30	0-15	158 (50)	2.7 (1.3)	2.0 (2.7)	5.5 (6.4)	ND	1.2 (0.9)	ND	1.0 (0.8)	ND
30	15-30	129 (45)	2.4 (0.6)	1.0 (1.3)	2.3 (0.9)	0.2 (0.1)	ND	ND	0.3 (0.1)	ND
35	0-15	98 (35)	3.0 (1.3)	0.7 (0.7)	7.1 (3.9)	ND	3.0 (1.5)	ND	0.9 (0.7)	ND
35	15-30	92 (37)	2.5 (2.0)	0.2 (0.2)	2.0 (1.5)	ND	1.0 (1.1)	ND	0.5 (0.5)	ND
39	0-15	114 (52)	1.9 (0.3)	0.9 (0.4)	3.5 (1.4)	ND	1.9 (1.2)	ND	0.4 (0.0)	ND
39	15-30	98 (40)	1.3 (0.6)	0.2 (0.1)	0.7 (0.4)	ND	0.4 (0.5)	ND	0.2 (0.1)	ND
43	0-15	72 (29)	1.1 (0.3)	0.4 (0.1)	3.7 (1.8)	ND	1.7 (0.8)	ND	0.6 (0.1)	ND
43	15-30	41 (16)	1.0 (0.6)	ND	0.8 (0.6)	ND	0.6 (0.4)	ND	0.4 (0.2)	ND
48	0-15	80 (45)	1.3 (0.6)	0.9 (0.5)	5.2 (4.2)	ND	1.3 (0.6)	ND	0.4 (0.3)	ND
48	15-30	39 (14)	0.7 (0.6)	0.9 (1.0)	2.5 (4.1)	ND	0.6 (0.3)	ND	0.3 (0.2)	ND
48	30-45	47 (26)	0.9 (0.8)	0.4 (0.2)	0.4 (0.5)	ND	0.4 (0.4)	ND	0.1 (0.2)	ND
48	45-60	39 (9)	0.8 (0.5)	0.2 (0.1)	0.9 (0.8)	ND	0.2 (0.2)	ND	0.2 (0.3)	ND
48	60-75	38 (24)	0.8 (0.4)	0.2 (0.1)	1.3 (1.0)	ND	0.4 (0.7)	ND	0.1 (0.2)	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		11 T/Ha Sludge Applied in 1976								
21	0-15	168 (111)*	4.6 (1.6)	7.3 (3.6)	23.0 (21.0)	ND**	3.2 (0.7)	0.3 (0.1)	2.7 (0.9)	ND
21	15-30	134 (113)	2.5 (2.0)	0.4 (0.3)	2.0 (2.0)	ND	0.9 (0.6)	ND	0.3 (0.5)	ND
26	0-15	128 (64)	6.1 (2.6)	8.6 (4.6)	19.8 (1.5)	0.2 (0.2)	3.9 (2.0)	0.4 (0.4)	4.9 (3.2)	ND
26	15-30	129 (92)	2.1 (1.8)	0.5 (0.1)	4.0 (0.4)	ND	1.0 (1.2)	ND	0.6 (0.7)	ND
30	0-15	127 (74)	3.5 (2.0)	8.5 (6.3)	16.8 (12.5)	ND	1.7 (0.8)	0.2 (0.1)	3.8 (3.4)	ND
30	15-30	97 (62)	2.0 (1.5)	0.5 (0.2)	1.6 (1.0)	ND	0.3 (0.5)	ND	0.5 (0.4)	ND
35	0-15	87 (39)	3.4 (2.6)	5.4 (3.6)	14.0 (7.1)	ND	2.4 (1.3)	0.6 (0.8)	3.0 (1.7)	ND
35	15-30	75 (54)	2.6 (1.9)	1.0 (0.5)	4.3 (2.8)	ND	1.0 (1.1)	0.2 (0.3)	0.9 (0.4)	ND
39	0-15	111 (76)	2.1 (0.6)	7.3 (4.0)	18.3 (2.7)	ND	2.8 (1.0)	0.2 (0.1)	3.0 (0.4)	ND
39	15-30	123 (101)	1.9 (1.1)	0.6 (0.3)	1.6 (1.3)	ND	1.5 (1.1)	ND	0.2 (0.1)	ND
43	0-15	78 (62)	1.1 (0.4)	5.1 (3.1)	14.2 (9.1)	ND	1.6 (0.9)	0.2 (0.1)	2.5 (1.4)	ND
43	15-30	47 (25)	0.8 (0.4)	1.1 (1.8)	0.9 (1.0)	ND	0.5 (0.6)	ND	0.9 (0.9)	ND
48	0-15	62 (47)	1.0 (0.4)	3.1 (1.0)	7.4 (1.3)	ND	1.8 (0.7)	ND	1.1 (0.7)	ND
48	15-30	47 (22)	0.9 (0.4)	0.3 (0.1)	0.6 (0.8)	ND	0.5 (0.3)	ND	0.2 (0.3)	ND
48	30-45	36 (5)	0.4 (0.1)	0.3 (0.1)	1.1 (0.7)	ND	0.2 (0.1)	ND	ND	ND
48	45-60	22 (6)	0.2 (0.1)	0.2 (0.1)	1.0 (0.9)	ND	0.1 (0.1)	ND	ND	ND
48	60-75	20 (8)	0.2 (0.1)	0.2 (0.2)	1.0 (0.7)	ND	0.1 (0.2)	ND	ND	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		11 T/Ha Sludge Applied in 1976 and 1977								
21	0-15	133 (72)*	5.2 (1.8)	7.4 (5.3)	17.0 (11.0)	ND**	2.1 (0.7)	0.2 (0.1)	3.7 (2.8)	ND
21	15-30	88 (47)	2.4 (1.5)	0.5 (0.4)	3.0 (1.0)	ND	1.1 (0.9)	ND	0.3 (0.5)	ND
26	0-15	152 (77)	4.7 (2.5)	8.4 (7.6)	30.0 (20.0)	0.2 (0.2)	2.2 (1.6)	0.3 (0.2)	4.6 (3.9)	ND
26	15-30	144 (112)	3.4 (0.9)	3.3 (4.5)	12.0 (15.0)	ND	0.7 (0.8)	ND	3.8 (4.1)	ND
30	0-15	126 (40)	3.5 (1.0)	9.0 (2.9)	23.6 (8.1)	0.1 (0.1)	1.7 (0.6)	0.2 (0.1)	4.9 (2.3)	ND
30	15-30	102 (38)	2.8 (0.4)	2.6 (2.6)	6.2 (3.8)	ND	0.2 (0.3)	ND	1.3 (0.7)	ND
35	0-15	111 (26)	1.8 (0.6)	14.0 (4.7)	24.4 (3.7)	ND	4.3 (1.9)	0.4 (0.2)	8.2 (4.2)	ND
35	15-30	110 (47)	4.9 (2.4)	1.3 (0.4)	6.2 (3.7)	ND	2.7 (1.8)	0.3 (0.4)	1.4 (0.5)	ND
39	0-15	117 (46)	2.0 (0.3)	13.8 (5.4)	24.7 (0.8)	ND	3.7 (1.4)	0.3 (0.0)	6.8 (2.0)	ND
39	15-30	110 (80)	2.0 (1.2)	1.0 (0.5)	2.9 (2.7)	ND	1.2 (1.0)	ND	0.4 (0.2)	ND
43	0-15	79 (45)	0.9 (0.1)	8.2 (2.6)	17.9 (12.1)	ND	2.2 (0.6)	0.2 (0.1)	4.4 (1.6)	ND
43	15-30	53 (24)	0.9 (0.4)	0.5 (0.5)	5.6 (7.3)	ND	0.6 (0.6)	ND	0.4 (0.4)	ND
48	0-15	101 (58)	1.3 (0.1)	16.0 (10.9)	30.1 (15.0)	ND	3.0 (1.2)	0.3 (0.1)	6.9 (4.6)	ND
48	15-30	68 (34)	1.2 (0.4)	4.4 (2.7)	8.0 (1.3)	ND	1.3 (0.5)	0.2 (0.0)	1.8 (1.2)	ND
48	30-45	50 (23)	1.4 (0.6)	2.8 (3.8)	4.9 (5.6)	ND	0.7 (0.4)	ND	0.9 (1.2)	ND
48	45-60	38 (10)	1.5 (0.9)	1.3 (1.2)	3.2 (4.0)	ND	0.6 (0.2)	ND	0.4 (0.5)	ND
48	60-75	36 (12)	0.8 (0.4)	1.3 (0.9)	3.0 (2.9)	ND	0.3 (0.1)	ND	0.4 (0.4)	ND

*Standard Deviation

**Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		22 T/Ha Sludge Applied in 1976								
21	0-15	148 (73)*	4.2 (1.8)	9.9 (8.0)	24.0 (16.0)	0.1 (0.1)	2.8 (1.4)	0.5 (0.3)	4.5 (3.8)	ND**
21	15-30	115 (51)	2.5 (1.0)	3.6 (6.8)	9.0 (13.0)	0.1 (0.1)	1.1 (1.4)	ND	1.3 (2.5)	ND
26	0-15	128 (43)	5.2 (2.1)	12.2 (4.4)	28.0 (13.0)	0.3 (0.2)	2.2 (1.5)	0.3 (0.1)	5.7 (1.8)	ND
26	15-30	83 (25)	1.8 (1.1)	3.4 (3.8)	7.8 (8.0)	ND	0.5 (0.1)	ND	2.8 (1.9)	ND
30	0-15	131 (54)	3.6 (1.1)	8.0 (0.9)	20.2 (5.6)	0.2 (0.2)	2.7 (1.3)	0.2 (0.1)	4.3 (0.7)	ND
30	15-30	107 (48)	1.8 (0.3)	0.9 (0.7)	2.4 (1.5)	0.2 (0.2)	0.6 (0.7)	ND	0.8 (0.2)	ND
35	0-15	111 (26)	1.8 (0.6)	14.0 (4.7)	24.4 (3.7)	ND	4.3 (1.9)	0.4 (0.2)	8.2 (4.2)	ND
35	15-30	102 (34)	1.4 (0.7)	2.4 (0.6)	6.2 (2.9)	ND	1.6 (0.7)	0.1 (0.1)	1.7 (0.5)	ND
39	0-15	117 (46)	2.0 (0.3)	13.8 (5.4)	24.7 (0.8)	ND	3.7 (1.4)	0.3 (0.0)	6.8 (2.0)	ND
39	15-30	114 (51)	1.8 (0.5)	22.2 (6.4)	26.2 (0.9)	ND	4.2 (0.9)	0.4 (0.1)	8.9 (2.0)	ND
43	0-15	80 (42)	1.0 (0.2)	8.9 (4.0)	21.8 (4.0)	ND	2.2 (0.6)	0.2 (0.0)	4.4 (0.4)	ND
43	15-30	76 (84)	0.8 (0.5)	0.6 (0.3)	1.4 (0.9)	ND	0.4 (0.5)	ND	0.2 (0.2)	ND
48	0-15	83 (31)	1.4 (1.1)	5.3 (2.0)	12.8 (4.2)	ND	2.5 (0.8)	0.2 (0.0)	3.3 (1.2)	ND
48	15-30	43 (11)	1.1 (0.6)	1.0 (0.6)	0.4 (0.8)	ND	0.6 (0.4)	ND	0.7 (0.2)	ND
48	30-45	42 (10)	0.8 (0.5)	1.3 (0.9)	2.2 (4.2)	ND	0.6 (0.4)	ND	0.6 (0.6)	ND
48	45-60	32 (8)	0.7 (0.4)	0.5 (0.1)	1.4 (0.3)	ND	0.3 (0.3)	0.1 (0.0)	0.2 (0.3)	ND
48	60-75	27 (10)	0.5 (0.3)	0.4 (0.1)	1.2 (0.6)	ND	0.4 (0.2)	ND	0.4 (0.3)	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth cm	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
		ppm								
		22 T/Ha Sludge Applied in 1976 and 1977								
21	0-15	141 (40)*	4.4 (1.5)	14.6 (5.1)	37.0 (13.0)	ND**	3.3 (1.1)	0.4 (0.1)	6.7 (2.5)	ND
21	15-30	85 (28)	1.9 (1.5)	0.7 (0.6)	4.0 (2.0)	ND	0.7 (0.4)	ND	0.3 (0.5)	ND
26	0-15	167 (68)	6.1 (2.3)	14.7 (5.5)	42.0 (2.0)	0.2 (0.2)	3.8 (1.9)	0.4 (0.2)	8.5 (3.1)	ND
26	15-30	89 (42)	1.9 (0.7)	0.9 (0.5)	3.0 (1.0)	0.2 (0.2)	1.9 (2.9)	ND	1.5 (1.0)	ND
30	0-15	126 (23)	3.3 (0.7)	20.5 (16.0)	49.0 (14.0)	0.3 (0.2)	3.2 (1.2)	0.6 (0.2)	14.1 (6.5)	ND
30	15-30	114 (31)	2.0 (0.5)	2.8 (3.4)	6.7 (8.7)	0.3 (0.3)	0.4 (0.5)	0.2 (0.1)	1.5 (1.1)	ND
35	0-15	94 (30)	1.6 (0.4)	13.7 (13.1)	22.2 (8.8)	ND	3.9 (1.7)	0.4 (0.3)	7.4 (3.7)	ND
35	15-30	96 (37)	1.3 (0.4)	9.1 (13.5)	11.7 (11.5)	ND	2.2 (2.3)	0.2 (0.2)	5.6 (7.3)	ND
39	0-15	115 (22)	1.9 (0.3)	23.6 (5.7)	27.2 (0.5)	ND	4.7 (1.3)	0.4 (0.0)	12.2 (1.3)	ND
39	15-30	82 (30)	1.6 (0.6)	1.8 (1.2)	5.2 (4.9)	ND	1.1 (0.8)	ND	0.7 (0.7)	ND
43	0-15	84 (15)	1.0 (0.1)	22.4 (5.2)	28.4 (1.8)	ND	2.9 (0.7)	0.4 (0.1)	8.8 (2.2)	ND
43	15-30	54 (17)	0.7 (0.3)	0.8 (0.6)	2.7 (1.9)	ND	0.4 (0.3)	0.1 (0.0)	0.8 (0.6)	ND
48	0-15	72 (14)	1.1 (0.6)	11.4 (4.4)	27.3 (9.3)	ND	2.3 (0.2)	0.3 (0.1)	6.0 (2.4)	ND
48	15-30	68 (26)	1.1 (0.8)	0.8 (0.5)	2.2 (4.0)	ND	0.4 (0.4)	ND	0.6 (0.3)	ND
48	30-45	37 (12)	1.0 (0.7)	0.6 (0.5)	2.4 (2.0)	ND	0.4 (0.4)	ND	0.5 (0.1)	ND
48	45-60	25 (9)	0.5 (0.3)	9.2 (17.4)	1.3 (1.9)	ND	0.2 (0.2)	ND	0.4 (0.1)	ND
48	60-75	38 (32)	0.7 (0.6)	1.1 (0.8)	2.9 (3.7)	ND	0.2 (0.2)	ND	0.8 (0.6)	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		54 T/Ha Sludge Applied in 1976								
21	0-15	113 (39)*	3.3 (1.5)	25.8 (4.3)	48.0 (13.0)	0.2 (0.2)	3.2 (1.1)	0.5 (0.1)	10.8 (2.2)	ND**
21	15-30	56 (10)	1.6 (1.0)	1.4 (1.5)	4.0 (1.0)	0.1 (0.1)	0.4 (0.3)	ND	ND	ND
26	0-15	105 (11)	6.1 (2.6)	20.8 (2.8)	41.0 (7.0)	0.1 (0.1)	4.0 (1.8)	0.4 (0.1)	8.3 (5.6)	ND
26	15-30	85 (19)	2.1 (0.9)	1.7 (0.8)	4.0 (2.0)	ND	0.5 (0.1)	ND	1.1 (0.4)	
30	0-15	92 (15)	2.7 (1.1)	26.6 (6.3)	40.1 (4.8)	0.1 (0.1)	3.3 (1.3)	0.5 (0.1)	11.2 (2.3)	ND
30	15-30	71 (29)	1.6 (0.5)	1.0 (0.3)	2.1 (0.9)	ND	0.8 (1.3)	ND	0.8 (0.3)	ND
35	0-15	88 (35)	1.7 (0.4)	26.4 (3.0)	27.7 (1.0)	ND	4.7 (0.7)	0.7 (0.3)	14.3 (7.5)	ND
35	15-30	75 (37)	1.3 (0.4)	3.9 (2.4)	7.6 (3.7)	ND	1.0 (0.9)	0.1 (0.1)	2.4 (1.1)	ND
39	0-15	105 (30)	1.6 (0.4)	38.5 (11.7)	27.6 (0.3)	ND	4.3 (1.0)	0.4 (0.1)	14.4 (4.1)	ND
39	15-30	81 (47)	1.5 (0.3)	1.2 (0.5)	1.9 (1.1)	ND	0.7 (0.6)	ND	0.4 (0.4)	ND
43	0-15	60 (10)	0.7 (0.2)	24.1 (6.5)	27.7 (1.8)	ND	2.4 (0.8)	0.3 (0.1)	8.5 (1.6)	ND
43	15-30	38 (14)	0.6 (0.2)	0.8 (0.6)	1.5 (1.1)	ND	0.2 (0.3)	ND	1.0 (1.2)	ND
48	0-15	47 (10)	0.5 (0.1)	21.2 (5.0)	35.0 (6.6)	ND	2.4 (0.9)	0.3 (0.1)	8.4 (2.7)	ND
48	15-30	32 (19)	1.0 (1.0)	2.1 (1.0)	6.0 (3.8)	ND	0.4 (0.5)	ND	0.6 (0.5)	ND
48	30-45	27 (12)	0.7 (0.6)	0.8 (0.6)	0.9 (1.0)	ND	0.2 (0.3)	ND	0.2 (0.4)	ND
48	45-60	33 (23)	0.8 (0.6)	0.6 (0.2)	1.2 (0.8)	ND	0.2 (0.2)	ND	0.4 (0.4)	ND
48	60-75	31 (16)	0.5 (0.4)	0.4 (0.2)	1.2 (0.4)	ND	ND	ND	0.2 (0.2)	ND

*Standard Deviation **Not Detectable (Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		99 T/Ha Sludge Applied in 1976								
21	0-15	137 (58)*	4.0 (1.1)	29.7 (21.0)	60.0 (39.0)	0.2 (0.2)	4.0 (2.3)	0.6 (0.3)	16.7 (11.9)	ND**
21	15-30	82 (44)	2.0 (0.7)	1.8 (1.3)	6.0 (3.0)	ND	ND	ND	0.7 (0.7)	ND
26	0-15	123 (46)	6.2 (1.2)	41.9 (7.4)	96.0 (21.0)	0.3 (0.2)	6.4 (1.6)	0.8 (0.2)	25.3 (9.7)	ND
26	15-30	70 (20)	2.3 (1.8)	1.5 (1.0)	6.0 (3.0)	0.1 (0.1)	0.6 (0.4)	ND	2.2 (1.1)	ND
30	0-15	102 (40)	3.8 (0.8)	67.0 (9.6)	74.6 (10.3)	0.2 (0.2)	5.0 (0.3)	0.8 (0.1)	26.7 (4.9)	ND
30	15-30	88 (32)	2.1 (0.4)	1.6 (0.8)	3.9 (1.7)	0.3 (0.5)	0.4 (0.4)	ND	1.0 (0.4)	ND
35	0-15	86 (31)	2.5 (1.5)	64.9 (12.6)	29.2 (0.4)	ND	5.3 (0.9)	2.6 (3.4)	28.3 (8.6)	ND
35	15-30	80 (37)	3.2 (2.8)	8.1 (5.2)	17.1 (8.0)	ND	1.6 (0.8)	0.4 (0.3)	4.3 (2.9)	ND
39	0-15	115 (59)	1.8 (0.4)	64.9 (18.2)	29.4 (0.9)	0.1 (0.1)	6.4 (1.2)	1.1 (1.1)	29.4 (11.6)	ND
39	15-30	91 (85)	1.1 (0.9)	1.4 (0.5)	3.4 (2.6)	ND	1.7 (2.1)	0.1 (0.1)	0.5 (0.3)	ND
43	0-15	64 (34)	0.9 (0.4)	34.8 (10.1)	25.3 (10.5)	ND	3.2 (1.6)	0.5 (0.1)	15.6 (2.1)	ND
43	15-30	44 (22)	0.9 (0.5)	0.7 (0.3)	2.4 (1.5)	ND	0.5 (0.3)	ND	0.8 (0.4)	ND
48	0-15	62 (18)	5.7 (9.3)	38.4 (22.0)	45.5 (4.0)	ND	3.7 (1.2)	0.5 (0.2)	15.8 (5.5)	ND
48	15-30	54 (15)	1.0 (0.2)	2.0 (0.7)	7.3 (3.0)	ND	0.7 (0.5)	ND	0.8 (0.5)	ND
48	30-45	32 (9)	1.0 (0.2)	1.1 (0.2)	0.7 (0.8)	ND	0.3 (0.1)	ND	0.2 (0.2)	ND
48	45-60	33 (21)	1.2 (0.3)	1.2 (0.7)	0.9 (1.8)	ND	0.2 (0.1)	ND	0.1 (0.2)	ND
48	60-75	22 (5)	0.6 (0.3)	0.4 (0.1)	1.3 (0.4)	ND	0.3 (0.3)	ND	0.2 (0.2)	ND

*Standard Deviation **Not Detectable

(Continued)

TABLE B-2. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm					ppm				
					99 T/Ha Sludge Applied in 1976 and 1977					
21	0-15	121 (58)*	4.8 (1.0)	59.2 (14.9)	108.0 (8.0)	ND**	4.9 (0.8)	0.9 (0.1)	33.4 (4.5)	ND
21	15-30	118 (102)	2.4 (1.1)	1.9 (0.7)	6.0 (1.0)	0.1 (0.1)	0.6 (0.6)	ND	1.2 (0.2)	ND
26	0-15	141 (98)	6.2 (3.3)	20.2 (18.9)	56.0 (59.0)	ND	3.3 (3.6)	0.5 (0.4)	16.9 (19.2)	ND
26	15-30	150 (148)	3.0 (2.0)	2.5 (1.5)	6.0 (3.0)	ND	0.6 (0.1)	ND	2.7 (1.3)	ND
30	0-15	130 (84)	4.6 (2.3)	62.1 (38.5)	80.2 (13.8)	0.2 (0.4)	4.8 (1.5)	0.9 (0.2)	28.7 (4.9)	ND
30	15-30	123 (108)	4.1 (1.7)	2.8 (0.6)	5.2 (1.0)	0.1 (0.1)	0.4 (0.4)	ND	1.7 (0.6)	ND
35	0-15	77 (30)	3.5 (2.1)	64.5 (43.6)	25.7 (8.7)	ND	5.5 (4.2)	3.6 (5.2)	33.5 (24.8)	ND
35	15-30	82 (55)	3.3 (1.7)	21.7 (22.9)	23.2 (6.1)	ND	2.4 (2.1)	0.8 (0.8)	11.3 (9.7)	ND
39	0-15	127 (57)	2.6 (1.6)	79.6 (23.9)	29.8 (0.4)	ND	8.2 (1.7)	1.9 (1.2)	35.6 (8.3)	ND
39	15-30	85 (81)	1.5 (0.9)	1.6 (0.9)	2.8 (2.2)	ND	0.7 (0.2)	ND	0.8 (0.8)	ND
43	0-15	85 (46)	1.0 (0.2)	73.0 (19.0)	31.7 (1.2)	ND	4.8 (1.4)	0.7 (0.3)	30.9 (7.5)	ND
43	15-30	75 (56)	1.1 (0.6)	2.8 (0.5)	7.4 (1.3)	ND	0.7 (0.2)	0.1 (0.0)	1.8 (0.4)	ND
48	0-15	71 (28)	1.0 (0.4)	44.7 (23.2)	46.9 (4.7)	ND	3.9 (1.5)	0.6 (0.3)	21.7 (10.3)	ND
48	15-30	72 (72)	1.0 (0.2)	4.5 (4.2)	11.1 (7.6)	ND	1.1 (1.0)	ND	2.1 (1.8)	ND
48	30-45	34 (14)	1.0 (0.6)	2.2 (1.2)	3.9 (4.5)	ND	0.5 (0.4)	ND	0.6 (0.5)	ND
48	45-60	31 (12)	0.6 (0.5)	1.9 (1.1)	4.4 (4.6)	ND	0.2 (0.4)	ND	0.6 (0.4)	ND
48	60-75	28 (10)	0.6 (0.5)	2.9 (3.8)	4.2 (3.5)	ND	0.2 (0.3)	ND	1.0 (1.3)	ND

*Standard Deviation **Not Detectable

TABLE B-3. DTPA EXTRACTED HEAVY METALS FROM SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1978

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
					No Sludge Applied					
21	0-15	106.1 (45.4)*	2.7 (0.8)	2.5 (2.8)	6.6 (0.4)	0.2 (0.1)	5.0 (3.5)	0.2 (0.1)	1.7 (1.6)	ND**
21	15-30	97.8 (58.4)	1.6 (1.2)	0.8 (0.5)	3.7 (2.7)	0.1 (0.1)	1.2 (0.9)	0.1 (0.0)	0.5 (0.1)	ND
21	30-45	69.6 (68.7)	0.8 (0.8)	0.6 (0.5)	1.1 (0.9)	0.1 (0.1)	1.4 (1.5)	0.1 (0.0)	0.3 (0.3)	ND
25	0-15	101.4 (64.0)	2.9 (0.9)	1.3 (0.6)	6.8 (2.7)	ND	2.7 (1.1)	0.1 (0.0)	0.7 (0.7)	ND
25	15-30	64.2 (24.7)	1.3 (0.4)	0.3 (0.1)	1.2 (0.5)	0.3 (0.5)	0.7 (0.5)	ND	0.2 (0.3)	ND
29	0-15	92.6 (52.7)	3.0 (1.1)	0.9 (0.2)	6.7 (1.8)	ND	1.4 (0.7)	0.2 (0.1)	1.2 (0.8)	ND
29	15-30	58.2 (42.0)	1.6 (0.9)	0.3 (0.1)	1.4 (0.4)	ND	0.5 (0.6)	0.2 (0.1)	0.8 (1.0)	ND
34	0-15	131.1 (118.6)	3.3 (0.6)	2.6 (3.7)	8.5 (8.4)	ND	3.4 (0.4)	0.2 (0.1)	1.4 (1.0)	ND
34	15-30	108.0 (110.4)	2.2 (0.5)	0.5 (0.3)	1.6 (1.0)	ND	1.1 (0.8)	ND	0.5 (0.5)	ND
38	0-15	45.4 (17.4)	1.3 (0.4)	1.0 (0.8)	5.8 (3.9)	ND	1.8 (0.7)	ND	1.7 (1.1)	ND
38	15-30	33.6 (15.7)	0.8 (0.3)	0.1 (0.2)	1.3 (0.9)	ND	0.9 (1.0)	ND	1.1 (0.5)	ND
42	0-15	41.8 (17.0)	0.7 (0.1)	0.8 (0.8)	4.3 (2.2)	ND	1.7 (0.6)	ND	1.3 (1.0)	ND
42	15-30	35.3 (10.8)	0.4 (0.2)	0.2 (0.1)	1.8 (2.0)	ND	1.1 (0.7)	ND	0.7 (0.5)	ND
46	0-15	49.8 (12.1)	2.1 (1.2)	0.3 (0.1)	5.2 (1.4)	ND	2.7 (1.2)	0.2 (0.1)	0.4 (0.4)	ND
46	15-30	40.6 (3.5)	2.4 (2.9)	ND	1.6 (0.9)	ND	0.6 (0.7)	0.2 (0.1)	0.2 (0.4)	ND
46	30-45	23.0 (11.9)	1.0 (0.4)	ND	1.1 (0.7)	ND	0.5 (0.6)	0.1 (0.1)	0.1 (0.2)	
46	45-60	25.3 (4.5)	1.3 (1.0)	ND	0.9 (0.5)	ND	0.6 (0.4)	0.1 (0.1)	0.1 (0.3)	
46	60-75	21.7 (10.1)	0.5 (0.3)	ND	0.8 (0.5)	ND	0.5 (0.4)	ND	0.1 (0.3)	
46	75-90	21.6 (14.9)	0.6 (0.3)	ND	0.6 (0.7)	ND	0.4 (0.2)	ND	0.1 (0.3)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
11 T/Ha Sludge Applied in 1976										
21	0-15	104.3 (63.9)*	2.5 (0.5)	10.9 (4.8)	26.0 (11.0)	ND**	4.7 (2.2)	0.2 (0.0)	4.5 (2.1)	ND
21	15-30	102.3 (81.0)	2.1 (0.8)	2.1 (1.1)	6.1 (3.9)	ND	1.2 (0.7)	0.1 (0.0)	1.0 (0.7)	ND
21	30-45	54.7 (39.8)	0.9 (0.6)	0.7 (0.2)	1.4 (1.4)	ND	0.4 (0.6)	ND	0.4 (0.2)	ND
25	0-15	110.9 (79.8)	3.4 (1.9)	11.8 (5.2)	25.7 (11.6)	0.4 (0.4)	2.8 (0.2)	0.3 (0.1)	4.0 (2.0)	3.1 (2.2)
25	15-30	95.6 (99.5)	2.5 (2.6)	1.1 (0.9)	3.7 (3.4)	0.3 (0.5)	1.1 (0.9)	0.1 (0.0)	1.1 (0.2)	ND
29	0-15	74.9 (73.0)	2.9 (1.9)	7.4 (6.1)	20.4 (16.4)	ND	1.5 (1.3)	0.2 (0.1)	4.4 (2.4)	ND
29	15-30	41.5 (39.7)	1.1 (1.0)	0.7 (0.2	7.0 (11.0)	ND	0.4 (0.3)	0.2 (0.1)	1.3 (0.9)	ND
34	0-15	47.1 (44.4)	4.7 (2.6)	12.1 (6.8)	27.8 (17.4)	ND	3.6 (0.5)	0.3 (0.2)	3.8 (2.5)	ND
34	15-30	24.3 (42.4)	3.7 (2.1)	1.4 (0.7)	3.8 (2.6)	ND	2.7 (1.6)	ND	0.5 (1.0)	ND
38	0-15	54.8 (32.9)	1.4 (0.6)	7.9 (5.2)	17.6 (10.1)	ND	2.4 (0.3)	0.2 (0.1)	4.3 (2.7)	ND
38	15-30	41.0 (24.1)	1.4 (0.8)	0.4 (0.2)	1.9 (1.4)	ND	1.8 (1.0)	ND	1.2 (0.5)	ND
42	0-15	45.6 (18.0)	0.7 (0.1)	10.9 (15.5)	20.8 (24.7)	ND	2.0 (0.6)	0.2 (0.2)	5.1 (5.9)	ND
42	15-30	28.9 (16.6)	0.4 (0.2)	5.2 (9.0)	7.8 (12.6)	ND	1.5 (0.1)	ND	2.9 (3.4)	ND
46	0-15	68.3 (55.1)	1.2 (0.5)	13.6 (21.4)	8.5 (6.8)	ND	5.6 (7.2)	0.3 (0.3)	2.3 (0.7)	ND
46	15-30	30.6 (11.6)	0.8 (0.6)	1.3 (2.1)	4.7 (4.4)	ND	0.4 (0.3)	ND	1.2 (0.8)	ND
46	30-45	28.4 (12.8)	0.7 (0.6)	1.6 (2.7)	7.8 (12.2)	ND	0.7 (0.9)	ND	0.9 (1.3)	
46	45-60	21.6 (5.4)	1.0 (0.7)	0.4 (0.5)	2.0 (2.2)	ND	0.1 (0.2)	ND	0.7 (0.6)	
46	60-75	26.2 (10.8)	0.6 (0.4)	0.4 (0.6)	2.3 (1.8)	ND	0.4 (0.5)	ND	0.2 (0.3)	
46	75-90	12.1 (8.2)	0.4 (0.2)	0.4 (0.5)	1.5 (0.8)	ND	0.2 (0.3)	ND	0.1 (0.1)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		11 T/Ha Sludge Applied in 1976, 1977, and 1978								
21	0-15	98.4 (32.3)*	2.7 (0.6)	27.0 (11.3)	89.6 (26.3)	ND**	10.1 (1.5)	0.6 (0.1)	13.8 (4.8)	ND
21	15-30	96.6 (48.4)	2.0 (1.2)	5.8 (1.1)	17.1 (7.0)	ND	2.7 (2.3)	0.1 (0.0)	2.4 (0.6)	ND
21	30-45	58.7 (44.1)	1.7 (1.8)	1.1 (0.5)	4.6 (1.1)	ND	0.6 (0.6)	0.1 (0.0)	0.7 (0.3)	ND
25	0-15	92.7 (46.0)	3.1 (0.9)	22.4 (5.8)	67.1 (22.6)	0.2 (0.2)	5.4 (2.4)	0.5 (0.0)	8.6 (2.0)	ND
25	15-30	102.6 (59.7)	3.2 (1.8)	2.6 (1.1)	21.8 (26.2)	0.3 (0.4)	3.4 (2.9)	0.2 (0.1)	2.0 (2.6)	ND
29	0-15	89.2 (59.8)	3.0 (0.6)	20.4 (3.3)	44.0 (28.2)	ND	5.0 (2.8)	0.2 (0.1)	11.2 (2.1)	ND
29	15-30	76.5 (77.7)	2.2 (1.5)	1.7 (1.0)	7.1 (4.2)	ND	0.7 (0.6)	0.2 (0.1)	2.0 (1.4)	ND
34	0-15	74.1 (20.4)	3.9 (1.7)	15.3 (8.3)	53.9 (22.5)	ND	3.9 (0.7)	0.5 (0.1)	8.2 (4.5)	ND
34	15-30	70.2 (13.6)	4.4 (4.3)	9.8 (13.8)	32.1 (44.0)	ND	4.6 (3.7)	0.3 (0.3)	4.8 (6.3)	ND
38	0-15	56.8 (13.9)	1.4 (0.3)	15.6 (2.9)	48.6 (12.9)	ND	3.7 (0.8)	0.3 (0.1)	9.5 (2.1)	ND
38	15-30	50.0 (22.9)	1.5 (0.9)	0.6 (0.4)	14.5 (22.5)	ND	1.6 (0.5)	ND	1.1 (0.3)	ND
42	0-15	33.7 (26.2)	0.4 (0.4)	8.4 (8.0)	20.5 (18.6)	ND	3.4 (4.1)	0.2 (0.2)	4.9 (5.6)	ND
42	15-30	23.7 (19.5)	0.3 (0.4)	1.2 (1.7)	4.3 (4.6)	ND	1.6 (1.3)	ND	1.6 (1.9)	ND
46	0-15	49.0 (35.8)	1.9 (1.2)	18.7 (24.4)	27.1 (6.0)	ND	9.8 (6.0)	0.4 (0.4)	10.6 (14.0)	ND
46	15-30	37.5 (29.6)	1.4 (1.1)	1.5 (2.0)	6.1 (5.1)	ND	1.2 (0.6)	ND	1.1 (1.0)	ND
46	30-45	22.0 (5.9)	0.9 (0.5)	1.7 (3.2)	7.3 (12.2)	ND	0.5 (0.5)	ND	1.1 (1.8)	
46	45-60	21.6 (5.4)	1.0 (0.7)	0.4 (0.5)	2.0 (2.2)	ND	0.1 (0.2)	ND	0.7 (0.6)	
46	60-75	14.8 (4.1)	0.6 (0.3)	0.6 (1.0)	2.4 (2.9)	ND	ND	ND	0.5 (0.5)	
46	75-90	10.0 (7.3)	0.4 (0.2)	0.5 (0.6)	1.5 (1.1)	ND	0.1 (0.2)	ND	0.1 (0.3)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
					22 T/Ha Sludge Applied in 1976					
21	0-15	127.8 (43.9)*	2.3 (0.9)	27.0 (12.6)	59.1 (24.0)	0.1 (0.1)	8.6 (3.5)	0.4 (0.2)	9.7 (5.7)	ND**
21	15-30	97.5 (86.0)	1.4 (1.4)	2.9 (2.2)	7.3 (4.5)	ND	2.3 (1.6)	ND	0.9 (0.4)	ND
21	30-45	73.9 (33.1)	1.3 (0.9)	2.4 (3.4)	5.4 (8.2)	ND	0.8 (1.1)	ND	1.1 (1.9)	ND
25	0-15	104.7 (56.0)	3.4 (1.0)	22.8 (6.5)	45.8 (9.3)	0.4 (0.3)	5.5 (1.0)	0.4 (0.1)	8.6 (2.4)	ND
25	15-30	89.4 (54.6)	2.2 (1.4)	1.8 (0.8)	4.7 (2.0)	ND	1.8 (1.2)	0.3 (0.2)	0.8 (0.6)	ND
29	0-15	89.8 (60.3)	2.5 (1.3)	11.6 (7.2)	24.2 (15.2)	0.2 (0.1)	2.9 (2.9)	0.1 (0.0)	6.3 (3.1)	ND
29	15-30	81.2 (64.5)	1.5 (0.9)	3.0 (3.7)	5.2 (5.4)	ND	0.6 (0.4)	0.1 (0.0)	2.7 (1.2)	ND
34	0-15	71.4 (28.5)	3.6 (1.0)	28.6 (8.8)	52.6 (14.4)	ND	3.9 (0.6)	0.5 (0.2)	8.5 (3.6)	ND
34	15-30	25.5 (49.4)	2.0 (1.4)	4.5 (2.5)	8.9 (6.0)	ND	3.2 (0.6)	ND	1.2 (0.7)	ND
38	0-15	45.9 (21.5)	0.9 (0.5)	9.5 (5.3)	20.0 (12.2)	ND	2.3 (0.4)	0.2 (0.0)	4.8 (2.6)	ND
38	15-30	34.2 (18.5)	0.5 (0.4)	0.7 (0.4)	1.8 (1.1)	ND	0.9 (0.8)	ND	1.1 (0.6)	ND
42	0-15	41.6 (5.6)	0.7 (0.3)	8.8 (5.1)	22.0 (11.7)	ND	2.2 (0.4)	0.2 (0.0)	3.9 (1.5)	ND
42	15-30	31.4 (4.7)	0.4 (0.1)	1.3 (0.8)	2.9 (1.1)	ND	1.1 (0.3)	ND	1.3 (1.1)	ND
46	0-15	48.5 (41.1)	1.4 (0.9)	9.0 (1.7)	24.4 (6.0)	ND	5.4 (5.6)	0.2 (0.2)	5.0 (1.3)	ND
46	15-30	24.0 (9.5)	0.7 (0.3)	0.8 (1.0)	3.0 (1.6)	ND	0.2 (0.5)	ND	0.4 (0.5)	ND
46	30-45	28.2 (13.1)	0.5 (0.1)	0.6 (0.3)	3.7 (1.0)	ND	ND	ND	0.2 (0.4)	
46	45-60	19.4 (7.5)	0.3 (0.1)	0.3 (0.3)	1.7 (1.1)	ND	ND	ND	0.1 (0.1)	
46	60-75	15.7 (5.9)	0.4 (0.1)	0.2 (0.1)	1.1 (0.7)	ND	ND	ND	ND	
46	75-90	13.9 (8.9)	0.3 (0.1)	0.2 (0.1)	1.2 (0.6)	ND	1.3 (2.3)	ND	ND	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm					ppm				
					22 T/Ha Sludge Applied in 1976, 1977, and 1978					
21	0-15	122.3 (25.3)*	2.6 (0.6)	40.6 (5.1)	136.3 (50.3)	0.2 (0.2)	5.1 (5.8)	0.7 (0.2)	22.7 (6.1)	ND**
21	15-30	95.7 (34.7)	1.3 (0.4)	9.2 (4.4)	21.7 (6.8)	0.2 (0.1)	2.2 (1.3)	0.1 (0.0)	2.8 (0.8)	ND
21	30-45	84.8 (56.5)	1.2 (0.3)	1.2 (1.2)	3.2 (2.7)	0.1 (0.1)	0.8 (0.7)	0.1 (0.0)	0.5 (0.6)	ND
25	0-15	82.5 (22.9)	2.6 (0.5)	39.0 (18.6)	130.3 (60.2)	ND	8.7 (1.7)	0.9 (0.4)	24.4 (11.4)	ND
25	15-30	66.0 (14.7)	1.2 (0.2)	2.0 (0.4)	7.1 (1.7)	0.2 (0.3)	0.8 (0.8)	0.1 (0.0)	0.9 (0.7)	ND
29	0-15	82.8 (32.0)	2.7 (0.5)	34.1 (22.0)	108.1 (76.0)	ND	6.2 (4.3)	0.1 (0.0)	21.2 (15.2)	ND
29	15-30	59.8 (13.3)	1.8 (1.2)	8.7 (11.3)	22.8 (24.9)	ND	1.6 (2.2)	0.1 (0.0)	4.9 (4.7)	ND
34	0-15	76.6 (29.5)	3.1 (0.7)	46.6 (25.2)	125.0 (77.1)	ND	10.0 (3.9)	0.8 (0.3)	20.8 (12.0)	ND
34	15-30	49.6 (21.7)	1.4 (0.3)	5.3 (4.3)	12.5 (7.3)	ND	3.1 (0.5)	ND	1.9 (0.9)	ND
38	0-15	43.9 (14.0)	1.0 (0.3)	33.4 (13.1)	76.8 (28.2)	ND	5.5 (3.3)	0.6 (0.3)	14.5 (5.8)	ND
38	15-30	30.8 (14.2)	0.5 (0.2)	1.5 (0.6)	3.5 (1.6)	ND	1.0 (1.2)	ND	1.1 (0.6)	ND
42	0-15	41.2 (10.2)	0.4 (0.2)	14.4 (5.3)	53.7 (78.6)	ND	2.0 (0.7)	0.2 (0.1)	6.6 (2.6)	ND
42	15-30	37.7 (12.9)	0.5 (0.3)	4.5 (3.2)	19.6 (27.6)	ND	1.7 (0.4)	0.1 (0.1)	2.9 (2.2)	ND
46	0-15	57.6 (24.9)	1.2 (0.5)	21.2 (14.6)	76.5 (52.2)	ND	5.6 (2.3)	0.2 (0.3)	14.6 (8.5)	ND
46	15-30	29.7 (12.5)	0.4 (0.1)	0.6 (0.5)	3.6 (1.9)	ND	0.2 (0.4)	ND	0.9 (0.9)	ND
46	30-45	23.5 (9.2)	0.5 (0.2)	0.9 (0.1)	3.7 (1.1)	ND	0.1 (0.2)	ND	0.2 (0.3)	
46	45-60	27.7 (13.0)	0.7 (0.5)	0.6 (0.6)	2.4 (2.7)	ND	ND	ND	0.3 (0.3)	
46	60-75	16.5 (4.6)	0.3 (0.1)	0.7 (0.7)	0.9 (0.8)	ND	0.1 (0.2)	ND	0.5 (0.1)	
46	75-90	16.1 (11.1)	0.4 (0.3)	0.3 (0.2)	1.2 (0.9)	ND	0.2 (0.4)	ND	ND	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		54 T/Ha Sludge Applied in 1976								
21	0-15	96.8 (45.4)*	1.9 (0.5)	55.2 (16.1)	81.1 (10.3)	0.1 (0.1)	8.7 (1.9)	0.6 (0.1)	18.2 (2.2)	ND**
21	15-30	79.6 (35.8)	1.4 (0.8)	12.4 (2.4)	21.2 (4.5)	ND	2.3 (0.8)	0.2 (0.1)	4.4 (1.7)	ND
21	30-45	35.7 (5.7)	0.7 (0.4)	0.8 (0.1)	1.5 (0.4)	ND	0.2 (0.2)	0.1 (0.0)	0.5 (0.4)	ND
25	0-15	82.0 (31.1)	2.5 (1.4)	37.8 (37.6)	74.9 (51.5)	0.2 (0.2)	6.5 (3.9)	0.7 (0.4)	17.9 (12.3)	ND
25	15-30	53.9 (25.9)	1.2 (0.4)	3.0 (1.9)	5.0 (3.2)	0.2 (0.3)	1.7 (0.4)	0.1 (0.0)	0.6 (1.1)	ND
29	0-15	124.9 (32.1)	3.0 (0.5)	44.6 (5.6)	63.3 (7.3)	0.1 (0.0)	6.2 (1.4)	0.2 (0.1)	16.3 (3.1)	ND
29	15-30	81.0 (65.7)	1.5 (0.4)	2.8 (1.2)	5.5 (3.1)	ND	0.4 (0.3)	0.1 (0.0)	2.0 (0.4)	ND
34	0-15	79.1 (14.7)	3.4 (0.6)	63.8 (12.4)	85.1 (10.7)	ND	8.7 (1.3)	1.0 (0.4)	21.4 (8.5)	ND
34	15-30	69.6 (27.5)	1.6 (0.2)	17.9 (7.0)	26.6 (9.0)	ND	3.8 (0.2)	0.2 (0.1)	3.8 (1.7)	ND
38	0-15	49.5 (9.8)	1.0 (0.2)	33.8 (6.7)	51.5 (4.6)	ND	3.4 (1.0)	0.4 (0.1)	12.7 (2.6)	ND
38	15-30	30.1 (9.1)	0.7 (0.4)	1.6 (0.6)	14.1 (23.3)	ND	1.3 (0.7)	ND	1.2 (0.9)	ND
42	0-15	28.3 (8.3)	0.4 (0.3)	17.4 (10.2)	47.6 (7.0)	ND	2.3 (1.0)	0.3 (0.2)	7.0 (4.2)	ND
42	15-30	25.3 (8.5)	0.5 (0.2)	4.0 (4.5)	7.6 (7.1)	ND	1.5 (0.4)	ND	2.1 (1.5)	ND
46	0-15	46.4 (10.5)	0.5 (0.2)	18.0 (7.2)	33.7 (12.5)	ND	4.5 (3.5)	0.3 (0.1)	7.8 (2.9)	ND
46	15-30	33.8 (12.8)	0.5 (0.2)	1.1 (0.7)	2.2 (1.8)	ND	0.8 (0.3)	ND	0.2 (0.5)	ND
46	30-45	19.0 (6.6)	0.3 (0.1)	0.5 (0.3)	1.4 (0.5)	ND	0.6 (0.5)	ND	0.3 (0.4)	
46	45-60	14.7 (5.2)	0.4 (0.1)	0.4 (0.2)	1.2 (0.3)	ND	0.4 (0.5)	ND	0.2 (0.3)	
46	60-75	16.5 (4.6)	0.3 (0.1)	0.7 (0.7)	0.9 (0.8)	ND	0.1 (0.2)	ND	0.5 (0.1)	
46	75-90	10.0 (7.3)	0.4 (0.2)	0.5 (0.6)	1.5 (1.1)	ND	0.1 (0.2)	ND	0.1 (0.3)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		99 T/Ha Sludge Applied in 1976								
21	0-15	81.7 (34.0)*	2.3 (1.0)	76.3 (56.3)	130.6 (95.4)	0.2 (0.1)	6.8 (5.9)	0.9 (0.6)	29.6 (21.7)	ND**
21	15-30	66.9 (29.1)	1.7 (0.9)	14.3 (13.9)	26.6 (21.5)	0.1 (0.0)	2.4 (0.5)	0.2 (0.1)	5.4 (4.1)	ND
21	30-45	60.0 (37.5)	1.1 (0.5)	5.2 (4.8)	7.0 (7.9)	ND	0.8 (0.6)	0.1 (0.0)	1.5 (1.5)	ND
25	0-15	91.1 (63.2)	2.6 (1.1)	67.1 (63.3)	107.4 (94.1)	ND	6.2 (3.8)	0.5 (0.5)	22.0 (18.1)	ND
25	15-30	69.8 (51.5)	1.4 (0.8)	7.0 (7.0)	9.4 (8.4)	ND	1.0 (0.8)	0.1 (0.0)	1.4 (2.0)	ND
29	0-15	77.4 (29.1)	2.7 (0.6)	59.0 (39.8)	90.9 (56.9)	0.3 (0.2)	7.6 (3.4)	0.2 (0.1)	25.6 (16.3)	ND
29	15-30	47.5 (18.7)	1.5 (0.4)	4.4 (3.2)	5.1 (4.0)	0.2 (0.1)	0.4 (0.4)	0.1 (0.0)	3.1 (1.9)	ND
34	0-15	101.4 (22.8)	2.4 (0.5)	49.1 (38.8)	85.3 (67.1)	ND	7.0 (6.9)	0.7 (0.4)	19.2 (15.5)	ND
34	15-30	33.3 (6.5)	3.4 (3.4)	15.2 (20.3)	26.0 (27.2)	ND	3.6 (0.3)	0.3 (0.2)	5.2 (6.6)	ND
38	0-15	48.5 (35.2)	1.0 (0.5)	41.3 (45.2)	54.2 (56.0)	ND	3.5 (2.1)	0.4 (0.4)	15.3 (15.6)	ND
38	15-30	43.0 (24.2)	0.9 (0.6)	14.8 (20.2)	78.6 (142.1)	ND	2.3 (1.5)	0.2 (0.2)	7.4 (7.9)	ND
42	0-15	36.2 (3.9)	0.4 (0.1)	41.6 (18.2)	58.9 (25.8)	ND	3.5 (1.8)	0.5 (0.1)	15.3 (6.7)	ND
42	15-30	25.5 (2.2)	0.5 (0.3)	6.6 (2.8)	10.5 (3.9)	ND	2.6 (1.5)	ND	3.1 (1.3)	ND
46	0-15	62.3 (53.3)	1.3 (1.3)	19.6 (14.6)	38.1 (27.1)	ND	5.0 (4.5)	0.2 (0.2)	11.0 (9.0)	ND
46	15-30	30.1 (9.4)	0.4 (0.3)	0.6 (0.6)	2.0 (1.1)	ND	0.7 (0.3)	ND	0.5 (0.4)	ND
46	30-45	23.7 (11.7)	0.5 (0.3)	0.9 (0.9)	1.9 (1.7)	ND	0.6 (0.5)	ND	0.4 (0.5)	
46	45-60	17.6 (4.9)	0.4 (0.2)	1.3 (2.1)	3.2 (4.1)	ND	0.5 (0.4)	ND	0.9 (1.2)	
46	60-75	15.8 (4.9)	0.6 (0.4)	0.3 (0.2)	1.2 (0.6)	ND	0.2 (0.3)	ND	0.4 (0.6)	
46	75-90	8.8 (1.0)	0.3 (0.3)	0.4 (0.4)	1.3 (0.8)	ND	0.5 (0.4)	0.2 (0.3)	0.2 (0.2)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-3. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm					ppm				
99, 81 and 140 T/Ha Sludge Applied in 1976, 1977 and 1978, Respectively										
21	0-15	63.9 (37.9)*	1.9 (0.4)	79.7 (21.7)	424.1 (77.3)	ND**	9.6 (2.9)	2.5 (1.0)	81.0 (11.8)	ND
21	15-30	109.5 (74.2)	2.1 (0.9)	27.8 (24.6)	104.3 (99.2)	ND	2.8 (0.3)	0.5 (0.5)	17.2 (14.2)	ND
21	30-45	58.1 (36.5)	0.9 (0.3)	8.7 (9.6)	30.3 (27.1)	0.1 (0.0)	6.6 (9.1)	0.2 (0.2)	5.0 (4.7)	ND
25	0-15	67.7 (30.6)	2.8 (0.3)	92.2 (15.4)	347.2 (68.1)	0.2 (0.3)	9.9 (2.6)	1.5 (0.8)	50.6 (11.5)	ND
25	15-30	78.2 (63.3)	2.0 (1.0)	9.0 (6.4)	26.9 (14.4)	ND	2.6 (0.9)	0.2 (0.1)	5.7 (3.6)	ND
29	0-15	87.3 (40.2)	3.6 (0.8)	87.1 (13.9)	138.2 (19.4)	ND	6.7 (4.4)	0.1 (0.0)	22.0 (15.4)	ND
29	15-30	76.1 (100.3)	3.7 (4.5)	10.4 (5.5)	37.6 (21.4)	ND	1.0 (0.9)	0.1 (0.0)	6.7 (1.8)	ND
34	0-15	47.8 (12.5)	2.3 (0.8)	93.1 (20.9)	404.6 (72.9)	ND	8.7 (10.5)	4.2 (2.1)	39.1 (24.5)	ND
34	15-30	52.6 (9.1)	1.8 (0.3)	23.6 (19.5)	74.9 (50.9)	ND	7.6 (7.9)	0.5 (0.3)	10.5 (8.0)	ND
38	0-15	45.2 (13.6)	1.6 (0.6)	99.7 (37.2)	202.1 (117.3)	ND	9.0 (1.3)	1.7 (0.6)	48.4 (19.3)	ND
38	15-30	34.3 (22.6)	1.1 (0.6)	7.7 (9.7)	16.0 (16.8)	ND	1.3 (1.0)	ND	4.6 (3.9)	ND
42	0-15	39.9 (3.5)	0.5 (0.1)	68.4 (32.7)	94.3 (90.5)	ND	7.6 (3.8)	1.0 (0.5)	30.0 (15.7)	ND
42	15-30	27.7 (4.5)	0.6 (0.5)	6.1 (4.7)	12.8 (9.6)	ND	1.6 (0.6)	ND	3.1 (2.8)	ND
46	0-15	45.0 (15.4)	0.9 (0.5)	44.3 (27.8)	145.0 (89.9)	ND	9.6 (6.6)	0.6 (0.8)	33.3 (22.2)	ND
46	15-30	39.7 (41.5)	0.6 (0.8)	3.9 (3.8)	14.2 (14.4)	ND	1.1 (0.8)	ND	2.2 (3.0)	ND
46	30-45	73.2 (105.3)	1.3 (1.9)	3.0 (3.9)	11.2 (16.2)	ND	1.2 (1.9)	ND	2.4 (3.8)	
46	45-60	26.1 (14.1)	0.7 (0.6)	1.1 (0.9)	4.0 (3.5)	ND	0.4 (0.5)	ND	0.8 (0.7)	
46	60-75	19.9 (7.9)	0.5 (0.1)	0.4 (0.3)	1.3 (0.6)	ND	0.2 (0.4)	ND	0.4 (0.4)	
46	75-90	14.8 (11.0)	0.4 (0.3)	0.7 (0.7)	2.8 (2.8)	ND	0.2 (0.4)	0.1 (0.2)	0.7 (0.7)	

*Standard Deviation **Not Detectable

TABLE B-4. HEAVY METAL CONTENT OF SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1976

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
					No Sludge Applied					
24	0-15	4890 (2490)*	49 (24)	36 (19)	19 (12)	16 (22)	ND**	ND	54 (22)	
	15-30	4490 (1320)	25 (9)	50 (10)	8 (5)	52 (42)	ND	ND	30 (22)	
28	0-15	5620 (2480)	32 (15)	6 (5)	13 (7)	6 (8)	13 (14)	ND	103 (43)	0.077 (0.017)
	15-30	2580 (535)	22 (6)	12 (3)	7 (6)	18 (4)	4 (5)	ND	30 (17)	0.090 (0.033)
45	0-15	5140 (1860)	44 (8)	17 (13)	16 (3)	13 (21)	10 (7)	2 (2)	12 (12)	0.122 (0.032)
	15-30	3420 (2030)	34 (10)	10 (3)	8 (4)	2 (3)	ND	ND	ND	0.127 (0.030)
					11 T/Ha Sludge Applied					
24	0-15	3820 (481)	56 (17)	40 (17)	24 (10)	31 (16)	ND	ND	50 (23)	
	15-30	5110 (1400)	31 (15)	38 (8)	7 (7)	47 (32)	ND	ND	28 (16)	
28	0-15	5070 (2314)	33 (6)	11 (7)	31 (8)	100 (178)	24 (30)	ND	88 (21)	0.068 (0.025)
	15-30	3200 (409)	24 (6)	12 (4)	8 (2)	28 (15)	2 (2)	ND	22 (19)	0.091 (0.064)
45	0-15	5440 (1410)	47 (10)	17 (4)	30 (8)	12 (6)	10 (10)	5 (4)	6 (3)	0.122 (0.023)
	15-30	4600 (1920)	50 (14)	12 (4)	13 (2)	2 (4)	ND	3 (4)	ND	0.123 (0.028)
					22 T/Ha Sludge Applied					
24	0-15	4940 (595)	52 (16)	60 (15)	32 (3)	72 (49)	ND	ND	58 (29)	
	15-30	4100 (420)	34 (19)	32 (17)	11 (5)	74 (61)	ND	ND	17 (20)	
28	0-15	5330 (1140)	38 (16)	20 (3)	69 (32)	68 (67)	11 (16)	ND	125 (19)	0.082 (0.009)
	15-30	2890 (553)	33 (7)	10 (6)	6 (3)	26 (15)	3 (4)	ND	26 (14)	0.087 (0.043)
45	0-15	4320 (1120)	50 (7)	21 (4)	50 (12)	15 (6)	3 (5)	8 (3)	15 (2)	0.122 (0.051)
	15-30	4100 (937)	38 (6)	14 (6)	9 (4)	ND	1 (1)	4 (3)	ND	0.098 (0.008)

*Standard Deviation **Not Detectable

(Continued)

TABLE B-4. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
					54 T/Ha Sludge Applied					
24	0-15	4420 (1370)*	62 (23)	44 (20)	30 (22)	89 (58)	ND**	ND	55 (44)	
	15-30	3840 (48)	25 (13)	44 (10)	12 (5)	45 (31)	ND	ND	31 (18)	
28	0-15	4980 (845)	42 (17)	30 (6)	81 (20)	159 (55)	10 (11)	ND	143 (53)	0.122 (0.051)
	15-30	2510 (272)	27 (7)	21 (11)	5 (4)	24 (24)	3 (4)	ND	26 (25)	0.079 (0.047)
45	0-15	4620 (822)	46 (23)	34 (8)	70 (23)	22 (11)	14 (13)	5 (5)	15 (10)	0.108 (0.015)
	15-30	2970 (1060)	35 (14)	12 (3)	13 (2)	3 (4)	ND	4 (4)	1 (3)	0.090 (0.020)
					99 T/Ha Sludge Applied					
24	0-15	4750 (1030)	36 (16)	48 (17)	66 (23)	115 (65)	ND	ND	47 (17)	
	15-30	4300 (754)	33 (17)	36 (20)	9 (7)	47 (24)	ND	ND	44 (7)	
28	0-15	5120 (639)	29 (18)	45 (15)	183 (109)	131 (36)	39 (49)	ND	177 (110)	0.055 (0.016)
	15-30	3480 (2040)	24 (2)	36 (14)	5 (4)	30 (12)	ND	ND	15 (12)	0.074 (0.015)
45	0-15	3940 (828)	46 (10)	63 (17)	140 (34)	66 (21)	18 (14)	6 (5)	64 (5)	0.127 (0.034)
	15-30	3200 (982)	44 (12)	18 (8)	30 (9)	10 (12)	1 (1)	3 (4)	ND	0.114 (0.009)

*Standard Deviation **Not Detectable

TABLE B-5. HEAVY METAL CONTENT OF SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1977

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
					No Sludge Applied					
21	0-15	3704 (654)*	57 (12)	35 (62)	38 (12)	62 (124)	11 (12)	ND**	10 (11)	0.9 (0.2)
21	15-30	2489 (470)	48 (10)	ND	28 (4)	ND	ND	ND	4 (3)	0.9 (0.2)
47	0-15	5200 (3966)	61 (54)	25 (24)	140 (46)	12 (6)	ND	1.3 (1.6)	6 (5)	2.0 (1.2)
47	15-30	3082 (1537)	31 (13)	16 (13)	45 (25)	9 (4)	ND	0.8 (1.2)	5 (6)	1.6 (1.1)
47	30-45	3391 (1939)	31 (16)	18 (19)	34 (11)	11 (8)	ND	0.7 (0.8)	8 (5)	
47	45-60	3258 (2131)	26 (10)	18 (20)	29 (15)	11 (7)	ND	1.4 (0.9)	6 (5)	
47	60-75	4685 (1322)	32 (5)	24 (23)	81 (70)	11 (4)	ND	1.4 (1.1)	10 (7)	
					11 T/Ha Sludge Applied in 1976					
21	0-15	6989 (3309)	63 (9)	11 (2)	55 (9)	13 (15)	22 (15)	ND	11 (8)	1.7 (1.0)
21	15-30	5420 (2661)	52 (12)	ND	27 (2)	ND	7 (15)	ND	5 (4)	1.1 (0.3)
47	0-15	4592 (2911)	59 (12)	31 (22)	343 (385)	30 (16)	7 (14)	0.9 (0.3)	10 (6)	1.5 (0.8)
47	15-30	3684 (2000)	44 (25)	12 (12)	45 (56)	12 (5)	ND	1.4 (1.1)	ND	1.6 (1.1)
47	30-45	3276 (1585)	29 (9)	13 (12)	31 (29)	11 (6)	ND	1.2 (0.9)	8 (6)	
47	45-60	4823 (2096)	37 (23)	15 (22)	83 (30)	10 (5)	ND	1.4 (0.9)	7 (6)	
47	60-75	3383 (1025)	33 (15)	13 (15)	22 (13)	9 (5)	ND	0.9 (0.8)	7 (6)	
					11 T/Ha Sludge Applied in 1976 and 1977					
21	0-15	5271 (2581)	71 (7)	89 (152)	52 (2)	8 (14)	36 (35)	ND	10 (6)	2.3 (0.7)
21	15-30	4526 (2533)	52 (5)	ND	32 (6)	ND	ND	ND	6 (5)	0.9 (0.2)
47	0-15	4054 (1359)	50 (8)	63 (46)	539 (582)	60 (38)	12 (8)	0.9 (0.7)	6 (9)	2.5 (1.7)
47	15-30	4265 (2619)	42 (6)	25 (16)	214 (240)	28 (8)	10 (20)	0.7 (0.8)	6 (4)	1.3 (0.9)
47	30-45	3396 (1571)	40 (14)	18 (18)	91 (109)	17 (5)	7 (14)	0.7 (0.9)	ND	
47	45-60	4231 (2429)	37 (22)	32 (19)	84 (76)	32 (23)	11 (14)	0.5 (0.6)	7 (5)	
47	60-75	4037 (2103)	36 (12)	20 (19)	40 (35)	17 (8)	7 (14)	1.3 (0.3)	3 (5)	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-5. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
22 T/Ha Sludge Applied in 1976										
21	0-15	3524 (1246)*	55 (6)	55 (61)	183 (129)	73 (85)	23 (32)	ND**	41 (36)	1.6 (1.2)
21	15-30	2691 (940)	54 (3)	12 (22)	42 (13)	8 (17)	ND	ND	ND	ND
47	0-15	4072 (626)	39 (9)	31 (20)	328 (336)	56 (60)	20 (21)	0.5 (1.0)	6 (7)	3.4 (1.0)
47	15-30	4603 (1891)	47 (11)	12 (11)	69 (54)	11 (5)	20 (24)	1.2 (1.0)	ND	ND
47	30-45	2863 (426)	28 (5)	8 (6)	61 (53)	11 (5)	8 (17)	1.0 (0.8)	ND	
47	45-60	4376 (2123)	39 (17)	10 (11)	44 (44)	10 (5)	ND	1.1 (0.3)	ND	
47	60-75	4507 (893)	34 (8)	11 (10)	38 (36)	10 (7)	ND	1.3 (0.3)	ND	
22 T/Ha Sludge Applied in 1976 and 1977										
21	0-15	4121 (731)	64 (8)	26 (12)	83 (27)	49 (24)	12 (14)	ND	17 (6)	1.1 (0.3)
21	15-30	3319 (947)	53 (9)	2 (2)	43 (10)	ND	ND	ND	ND	0.9 (0.2)
47	0-15	3953 (1160)	51 (24)	46 (20)	360 (296)	58 (53)	21 (21)	0.9 (0.8)	8 (7)	2.4 (1.4)
47	15-30	4050 (3971)	35 (11)	5 (2)	46 (28)	12 (8)	16 (12)	0.7 (0.9)	7 (2)	0.9 (0.4)
47	30-45	3838 (2673)	32 (4)	8 (3)	44 (40)	11 (6)	7 (14)	0.2 (0.4)	ND	
47	45-60	3996 (2515)	42 (19)	10 (5)	57 (60)	10 (6)	11 (14)	0.4 (0.4)	ND	
47	60-75	3291 (1337)	25 (6)	8 (6)	34 (25)	8 (6)	ND	0.6 (1.3)	ND	
54 T/Ha Sludge Applied in 1976										
21	0-15	3598 (676)	61 (7)	49 (28)	124 (32)	63 (33)	ND	ND	32 (17)	1.6 (1.2)
21	15-30	3164 (866)	46 (8)	ND	42 (12)	ND	ND	ND	ND	0.8 (0.2)
47	0-15	3941 (906)	45 (8)	96 (61)	604 (490)	112 (80)	21 (25)	0.7 (0.1)	15 (17)	3.1 (2.0)
47	15-30	2791 (1374)	40 (20)	12 (17)	124 (122)	13 (3)	ND	0.6 (0.4)	13 (25)	1.6 (1.1)
47	30-45	3249 (1472)	34 (14)	10 (16)	56 (50)	8 (2)	ND	0.7 (0.1)	ND	
47	45-60	2991 (1071)	27 (11)	11 (15)	57 (60)	9 (6)	ND	1.1 (0.6)	ND	
47	60-75	3662 (2038)	32 (16)	10 (16)	47 (34)	9 (5)	ND	0.9 (0.8)	ND	

*Standard Deviation **Not Detectable

(Continued)

TABLE B-5. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
99 T/Ha Sludge Applied in 1976										
21	0-15	3715 (365)*	58 (10)	75 (15)	200 (13)	101 (17)	35 (15)	ND**	58 (16)	3.6 (3.5)
21	15-30	2022 (551)	50 (7)	3 (3)	39 (8)	ND	8 (17)	ND	8 (1)	1.4 (1.2)
47	0-15	4240 (513)	46 (11)	126 (68)	828 (484)	140 (89)	36 (21)	1.9 (0.9)	23 (17)	5.0 (2.6)
47	15-30	1990 (184)	28 (5)	9 (10)	118 (69)	15 (4)	ND	1.0 (0.8)	ND	1.6 (1.1)
47	30-45	2581 (885)	34 (25)	12 (5)	87 (35)	14 (7)	12 (16)	0.2 (0.3)	ND	
47	45-60	3822 (983)	39 (15)	11 (12)	42 (42)	16 (6)	8 (9)	1.0 (1.3)	ND	
47	60-75	3444 (465)	25 (16)	9 (7)	63 (40)	12 (5)	ND	1.3 (1.9)	ND	
99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively										
21	0-15	3692 (232)	66 (12)	13 (12)	56 (19)	17 (20)	5 (10)	ND	8 (7)	3.3 (2.6)
21	15-30	4278 (2195)	54 (8)	ND	44 (13)	ND	ND	ND	ND	2.0 (1.3)
47	0-15	5247 (1555)	46 (5)	156 (50)	980 (890)	220 (79)	39 (27)	0.9 (0.7)	52 (46)	5.1 (1.1)
47	15-30	4565 (1893)	30 (8)	37 (38)	25 (28)	54 (64)	12 (8)	0.7 (0.9)	36 (56)	2.1 (1.6)
47	30-45	3632 (1158)	37 (8)	12 (6)	66 (60)	13 (9)	ND	0.7 (0.8)	10 (5)	
47	45-60	3797 (1229)	32 (11)	15 (12)	61 (43)	16 (11)	ND	0.3 (0.7)	6 (5)	
47	60-75	4429 (2328)	42 (20)	14 (11)	144 (111)	17 (12)	ND	0.3 (0.4)	8 (6)	

*Standard Deviation **Not Detectable

TABLE B-6. HEAVY METAL CONTENT OF SOIL SAMPLES FROM SLUDGE TREATMENTS IN 1978

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		No Sludge Applied								
21	0-15	4546 (1493)*	46 (2)	12 (5)	22 (3)	24 (6)	14 (18)	ND**	8 (5)	ND
21	15-30	4066 (1635)	41 (12)	8 (2)	13 (4)	18 (6)	ND	ND		ND
21	30-45	3184 (1677)	38 (8)	8 (2)	6 (2)	17 (4)	ND	ND	ND	
46	0-15	3954 (41)	45 (12)	8 (5)	16 (8)	18 (2)	ND	ND	ND	1.1 (0.4)
46	15-30	4023 (2150)	40 (7)	8 (4)	7 (1)	11 (5)	ND	ND	ND	3.8 (5.0)
46	30-45	5270 (2317)	36 (12)	9 (5)	9 (0.3)	11 (4)	ND	ND	ND	
46	45-60	5744 (3357)	49 (34)	9 (5)	8 (2)	12 (4)				
46	60-75	4491 (2862)	36 (16)	9 (5)	7 (2)	9 (4)				
46	75-90	5316 (2406)	42 (19)	9 (5)	8 (0.7)	9 (4)				
		11 T/Ha Sludge Applied in 1976								
21	0-15	5954 (849)	66 (6)	22 (6)	41 (8)	117 (170)	24 (37)	ND	27 (44)	ND
21	15-30	4090 (1542)	45 (5)	10 (2)	19 (4)	17 (4)	9 (8)	ND	ND	ND
21	30-45	3178 (1589)	46 (16)	6 (2)	7 (1)	20 (8)	ND	ND	ND	
46	0-15	3783 (2797)	39 (6)	38 (43)	39 (10)	78 (90)	ND	ND	ND	1.7 (1.3)
46	15-30	2125 (2009)	36 (5)	9 (6)	13 (1)	23 (8)	ND	ND	ND	0.8 (0.2)
46	30-45	2417 (2158)	28 (9)	10 (10)	10 (1)	20 (9)	ND	ND	ND	
46	45-60	2453 (1542)	37 (25)	8 (6)	8 (3)	16 (9)				
46	60-75	2298 (878)	27 (21)	8 (5)	7 (2)	12 (11)				
46	75-90	3151 (2066)	31 (18)	8 (6)	8 (2)	11 (10)				

*Standard Deviation **Not Detectable (Continued)

TABLE B-6. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		11 T/Ha Sludge Applied in 1976, 1977, and 1978								
21	0-15	5070 (2243)*	63 (3)	55 (5)	107 (16)	79 (20)	16 (22)	ND	18 (7)	ND**
21	15-30	3370 (1808)	52 (18)	19 (3)	24 (6)	26 (4)	14 (18)	ND	7 (3)	ND
21	30-45	2412 (1614)	48 (27)	9 (3)	7 (2)	16 (4)	19 (27)	ND	6 (2)	
46	0-15	3999 (3855)	40 (10)	39 (29)	497 (27)	70 (61)	6 (11)	ND	13 (25)	1.4 (0.5)
46	15-30	2539 (2971)	32 (9)	10 (7)	216 (281)	20 (12)	ND	ND	ND	1.0 (0.4)
46	30-45	3111 (3183)	33 (14)	10 (9)	238 (346)	24 (9)	ND	ND	ND	
46	45-60	3757 (2568)	30 (6)	8 (4)	98 (96)	17 (6)				
46	60-75	3162 (1894)	38 (25)	9 (7)	78 (61)	16 (7)				
46	75-90	2924 (1751)	37 (21)	8 (4)	63 (21)	13 (11)				
		22 T/Ha Sludge Applied in 1976								
21	0-15	4174 (1628)	49 (11)	45 (19)	76 (36)	58 (18)	23 (22)	ND	8 (6)	1.4 (1.4)
21	15-30	3543 (1542)	49 (14)	12 (5)	18 (6)	24 (9)	11 (13)	ND	ND	ND
21	30-45	2799 (980)	34 (7)	9 (3)	7 (2)	19 (5)	ND	ND	ND	
46	0-15	2881 (1261)	42 (12)	25 (16)	52 (6)	36 (33)	ND	ND	ND	1.1 (0.6)
46	15-30	3104 (3219)	26 (12)	8 (3)	10 (3)	12 (11)	ND	ND	ND	0.8 (0.2)
46	30-45	3133 (2355)	26 (13)	8 (3)	10 (4)	10 (9)	ND	ND	ND	
46	45-60	2795 (1555)	30 (10)	7 (3)	9 (3)	9 (7)				
46	60-75	3740 (1657)	45 (13)	7 (2)	8 (0.3)	8 (8)				
46	75-90	3621 (1513)	36 (13)	7 (2)	10 (1)	6 (7)				

*Standard Deviation **Not Detectable

(Continued)

TABLE B-6. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		22 T/Ha Sludge Applied in 1976, 1977, and 1978								
21	0-15	4443 (1291)*	60 (10)	65 (8)	158 (44)	92 (15)	25 (26)	ND	20 (12)	4.5 (3.0)
21	15-30	3487 (1263)	46 (3)	22 (7)	27 (5)	35 (4)	11 (13)	ND	7 (2)	1.0 (0.6)
21	30-45	2954 (982)	57 (9)	13 (6)	8 (3)	19 (6)				
46	0-15	5094 (1668)	42 (7)	54 (45)	115 (59)	128 (127)	ND**	ND	23 (22)	1.9 (0.8)
46	15-30	2496 (974)	32 (5)	7 (2)	17 (6)	12 (12)	ND	ND	ND	ND
46	30-45	3315 (1590)	29 (4)	8 (4)	17 (4)	16 (12)				
46	45-60	4788 (484)	36 (14)	8 (4)	12 (2)	13 (10)				
46	60-75	3905 (1342)	33 (7)	10 (5)	9 (1)	11 (9)				
46	75-90	3790 (957)	30 (16)	7 (2)	9 (1)	10 (10)				
		54 T/Ha Sludge Applied in 1976								
21	0-15	3732 (583)	53 (6)	76 (14)	122 (16)	78 (10)	48 (9)	ND	19 (12)	1.0 (0.6)
21	15-30	2999 (509)	48 (14)	22 (4)	28 (6)	28 (5)	23 (26)	ND	ND	ND
21	30-45	2099 (511)	44 (8)	8 (4)	7 (2)	15 (5)				
46	0-15	4553 (1115)	41 (7)	43 (16)	472 (282)	50 (28)	ND	ND	5 (5)	1.2 (0.4)
46	15-30	3553 (802)	36 (5)	11 (5)	75 (32)	20 (14)	ND	ND	ND	1.7 (1.6)
46	30-45	3682 (1017)	38 (6)	8 (4)	39 (44)	15 (13)				
46	45-60	3986 (1150)	35 (5)	8 (4)	33 (31)	15 (13)				
46	60-75	5666 (2532)	47 (16)	7 (4)	65 (46)	13 (12)				
46	75-90	5646 (3054)	58 (40)	9 (3)	46 (31)	13 (12)				

*Standard Deviation **Not Detectable

(Continued)

TABLE B-6. (Continued)

Week	Depth	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	cm	ppm								
		99 T/Ha Sludge Applied in 1976								
21	0-15	3822 (1782)*	45 (23)	169 (194)	440 (612)	227 (278)	59 (65)	ND	75 (70)	3.7 (2.6)
21	15-30	2367 (599)	36 (5)	38 (25)	48 (39)	43 (23)	23 (22)	ND	8 (2)	ND**
21	30-45	2013 (857)	37 (4)	14 (4)	9 (3)	19 (5)				
46	0-15	3782 (1506)	35 (7)	28 (19)	266 (298)	39 (24)	3 (6)	ND	5 (6)	2.1 (1.4)
46	15-30	2858 (1911)	30 (5)	10 (6)	60 (49)	9 (11)	ND	ND	ND	0.8 (0.2)
46	30-45	2592 (1558)	32 (8)	10 (8)	62 (47)	11 (10)				
46	45-60	3206 (1937)	37 (5)	8 (5)	74 (80)	8 (6)				
46	60-75	4160 (1369)	33 (9)	12 (8)	62 (42)	7 (5)				
46	75-90	2832 (1612)	34 (20)	10 (6)	44 (23)	6 (5)				
		99, 81 and 140 T/Ha Sludge Applied in 1976, 1977 and 1978, Respectively								
21	0-15	5577 (805)	59 (10)	203 (22)	869 (164)	250 (54)	85 (31)	ND	100 (0)	10.5 (6.3)
21	15-30	3226 (1611)	46 (7)	43 (25)	94 (88)	50 (34)	24 (15)	ND	16 (14)	1.0 (0.6)
21	30-45	2450 (1224)	41 (5)	18 (3)	22 (13)	24 (4)				
46	0-15	4293 (3595)	42 (4)	62 (45)	1337 (2657)	112 (115)	ND	ND	14 (11)	2.3 (1.6)
46	15-30	2727 (1658)	34 (8)	14 (14)	148 (119)	26 (30)	ND	ND	ND	1.1 (0.6)
46	30-45	3460 (2095)	32 (8)	10 (6)	250 (223)	14 (10)				
46	45-60	2973 (2118)	47 (18)	9 (4)	113 (81)	10 (5)				
46	60-75	3168 (2392)	35 (14)	8 (4)	48 (54)	9 (4)				
46	75-90	3559 (3865)	45 (36)	8 (4)	79 (70)	7 (5)				

*Standard Deviation **Not Detectable

TABLE B-7. KJELDAHL N, SPECIFIC CONDUCTIVITY, AND pH OF SOIL SAMPLES FROM THE SLUDGE TREATMENTS IN 1976

Week	Depth	Kjeldahl N	Spec. Cond.	pH
	cm	ppm	umhos/cm	
		No Sludge Applied		
24	0-15	1030 (225)*	1,006 (190)	5.3 (0.3)
	15-30	638 (164)	640 (140)	5.1 (0.5)
28	0-15	1260 (353)	900 (100)	5.8 (0.2)
	15-30	547 (170)	700 (100)	5.2 (0.5)
45	0-15	853 (137)	650 (70)	6.2 (0.3)
	15-30	469 (76)	540 (20)	5.6 (0.3)
		11 T/Ha Sludge Applied		
24	0-15	928 (263)	1,350 (100)	5.5 (0.5)
	15-30	686 (86)	760 (150)	5.0 (0.2)
28	0-15	1450 (604)	1,060 (180)	5.9 (0.2)
	15-30	730 (223)	800 (140)	5.2 (0.2)
45	0-15	1020 (79)	710 (100)	6.2 (0.4)
	15-30	597 (52)	660 (90)	5.5 (0.1)
		22 T/Ha Sludge Applied		
24	0-15	1270 (366)	520 (320)	5.3 (0.4)
	15-30	694 (452)	1,030 (150)	5.1 (0.3)
28	0-15	1030 (309)	970 (110)	6.0 (0.3)
	15-30	623 (143)	900 (1,600)	5.0 (0.2)
45	0-15	908 (145)	770 (70)	6.2 (0.3)
	15-30	546 (83)	780 (80)	5.4 (0.1)
		54 T/Ha Sludge Applied		
24	0-15	1100 (349)	1,800 (210)	5.7 (0.4)
	15-30	575 (281)	1,260 (400)	5.0 (0.2)
28	0-15	1300 (338)	1,200 (50)	6.2 (0.4)
	15-30	433 (134)	960 (2,200)	5.2 (0.2)
45	0-15	1110 (225)	930 (40)	6.2 (0.2)
	15-30	417 (126)	840 (140)	5.7 (0.3)

*Standard Deviation

(Continued)

TABLE B-7. (Continued)

Week	Depth	Kjeldahl N	Spec. Cond.	pH
	cm	umhos/cm		
		99 T/Ha Sludge Applied		
24	0-15	1430 (658)*	2,600 (800)	5.9 (0.4)
	15-30	675 (243)	1,690 (400)	5.1 (0.6)
28	0-15	1650 (688)	1,580 (50)	6.1 (0.3)
	15-30	783 (380)	1,330 (2,600)	4.8 (0.2)
45	0-15	1060 (272)	1,320 (130)	6.2 (0.4)
	15-30	657 (219)	980 (260)	5.3 (0.1)

*Standard Deviation

TABLE B-8. KJELDAHL N, SPECIFIC CONDUCTIVITY, AND pH OF SOIL SAMPLES FROM THE SLUDGE TREATMENTS IN 1977

Week	Depth	Kjeldahl N	Spec. Cond.	pH
	cm	ppm	umhos/cm	
No Sludge Applied				
21	0-15	1213 (47)*	2028 (380)	6.1 (0.5)
21	15-30	617 (53)	1170 (149)	5.7 (0.2)
26	0-15	1247 (251)		6.1 (0.3)
26	15-30	767 (179)		5.6 (0.5)
47	0-15	1028 (251)	851 (89)	6.1 (0.5)
47	15-30	575 (511)	620 (186)	6.0 (0.6)
47	30-45	548 (560)	651 (228)	5.9 (0.8)
47	45-60	288 (181)	541 (155)	6.0 (0.4)
47	60-75	562 (528)	711 (280)	5.9 (0.3)
11 T/Ha Sludge Applied in 1976				
21	0-15	1562 (247)	2539 (333)	6.1 (0.5)
21	15-30	733 (125)	1220 (259)	5.6 (0.3)
26	0-15	1672 (818)		6.2 (0.4)
26	15-30	740 (182)		5.5 (0.3)
47	0-15	1603 (353)	1307 (413)	6.6 (0.4)
47	15-30	494 (173)	701 (121)	6.3 (0.7)
47	30-45	438 (161)	576 (178)	6.0 (0.4)
47	45-60	219 (118)	456 (100)	5.8 (0.2)
47	60-75	110 (44)	476 (107)	5.8 (0.2)
11 T/Ha Sludge Applied in 1976 and 1977				
21	0-15	1247 (164)	2601 (638)	6.2 (0.3)
21	15-30	603 (134)	1269 (201)	5.7 (0.3)
26	0-15	1247 (455)		6.1 (0.1)
26	15-30	863 (342)		5.6 (0.4)
47	0-15	1740 (682)	1144 (236)	6.4 (0.1)
47	15-30	808 (221)	804 (265)	6.0 (0.4)
47	30-45	315 (247)	722 (452)	5.8 (0.4)
47	45-60	274 (134)	563 (236)	5.7 (0.3)
47	60-75	219 (89)	576 (216)	5.8 (0.3)

*Standard Deviation

(Continued)

TABLE B-8. (Continued)

Week	Depth cm	Kjeldahl N ppm	Spec. Cond. umhos/cm	pH
		22 T/Ha Sludge Applied in 1976		
21	0-15	1281 (419)*	1941 (504)	5.9 (0.2)
21	15-30	712 (261)	1493 (451)	5.5 (0.5)
26	0-15	1206 (228)		6.2 (0.3)
26	15-30	616 (176)		5.5 (0.3)
47	0-15	1288 (315)	944 (115)	6.5 (0.2)
47	15-30	507 (130)	733 (104)	6.0 (0.2)
47	30-45	370 (82)	626 (127)	6.1 (0.5)
47	45-60	288 (122)	512 (81)	6.0 (0.4)
47	60-75	192 (71)	620 (130)	6.0 (0.7)
		22 T/Ha Sludge Applied in 1976 and 1977		
21	0-15	1370 (118)	3534 (465)	6.1 (0.3)
21	15-30	667 (57)	1381 (326)	5.3 (0.2)
26	0-15	1357 (221)		6.4 (0.5)
26	15-30	521 (95)		5.3 (0.2)
47	0-15	1672 (263)	1264 (326)	6.5 (0.5)
47	15-30	658 (249)	746 (215)	5.4 (0.1)
47	30-45	288 (82)	586 (108)	5.5 (0.2)
47	45-60	164 (44)	552 (193)	5.7 (0.3)
47	60-75	151 (93)	623 (80)	5.7 (0.3)
		54 T/Ha Sludge Applied in 1976		
21	0-15	1508 (479)	2327 (380)	6.8 (0.7)
21	15-30	589 (104)	1170 (326)	5.8 (0.2)
26	0-15	1398 (230)		6.6 (0.3)
26	15-30	617 (69)		5.6 (0.2)
47	0-15	1192 (586)	1632 (418)	7.1 (0.3)
47	15-30	507 (302)	638 (163)	6.6 (0.7)
47	30-45	342 (291)	602 (206)	6.5 (0.6)
47	45-60	206 (113)	507 (76)	6.4 (0.7)
47	60-75	137 (54)	548 (63)	6.4 (0.7)

*Standard Deviation

(Continued)

TABLE B-8. (Continued)

Week	Depth	Kjeldahl N	Spec. Cond.	pH
	cm	ppm	umhos/cm	
		99 T/Ha Sludge Applied in 1976		
21	0-15	1480 (390)*	3273 (495)	6.6 (0.2)
21	15-30	589 (104)	1257 (248)	5.3 (0.1)
26	0-15	1768 (1000)		6.5 (0.3)
26	15-30	672 (221)		5.1 (0.3)
47	0-15	1836 (804)	1622 (734)	6.7 (0.4)
47	15-30	616 (197)	701 (38)	5.7 (0.4)
47	30-45	425 (93)	804 (265)	5.4 (0.6)
47	45-60	397 (144)	732 (115)	5.5 (0.4)
47	60-75	192 (32)	708 (121)	5.5 (0.3)
		99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively		
21	0-15	2042 (523)	6558 (1155)	6.8 (0.2)
21	15-30	699 (255)	2290 (375)	5.3 (0.1)
26	0-15	1466 (251)		6.3 (0.2)
26	15-30	795 (221)		5.4 (0.3)
47	0-15	1808 (465)	2042 (691)	6.6 (0.3)
47	15-30	1165 (1027)	1116 (339)	5.7 (0.5)
47	30-45	576 (381)	953 (292)	5.6 (0.3)
47	45-60	356 (71)	1012 (142)	5.5 (0.3)
47	60-75	233 (69)	856 (135)	5.5 (0.4)

*Standard Deviation

TABLE B-9. KJELDAHL N, SPECIFIC CONDUCTIVITY, AND pH OF SOIL SAMPLES FROM THE SLUDGE TREATMENTS IN 1978

Week	Depth cm	Kjeldahl N ppm	Spec. Cond. umhos/cm	pH
		No Sludge Applied		
21	0-15	1134 (292)*	1115 (283)	6.4 (0.2)
21	15-30	826 (372)	819 (196)	6.2 (0.3)
21	30-45	583 (355)	747 (102)	6.2 (0.4)
25	0-15	962 (143)	1125 (286)	6.6 (0.2)
25	15-30	1011 (510)	1235 (404)	5.9 (0.4)
46	0-15	1066 (167)	1046 (206)	6.5 (0.1)
46	15-30	477 (238)	950 (260)	6.0 (0.1)
46	30-45	398 (183)	890 (127)	5.6 (0.3)
46	45-60	239 (80)	968 (246)	5.5 (0.4)
46	60-75	143 (61)	943 (281)	5.6 (0.6)
46	75-90	127 (37)	987 (190)	5.4 (0.2)
		11 T/Ha Sludge Applied in 1976		
21	0-15	2123 (1278)	1088 (223)	6.8 (0.4)
21	15-30	632 (239)	871 (404)	6.5 (0.7)
21	30-45	648 (370)	734 (78)	6.1 (0.5)
25	0-15	1157 (372)	1250 (332)	6.6 (0.1)
25	15-30	865 (277)	1266 (100)	5.8 (0.1)
46	0-15	1495 (855)	1239 (454)	6.8 (0.4)
46	15-30	350 (156)	970 (355)	6.5 (0.5)
46	30-45	350 (156)	917 (353)	5.8 (0.7)
46	45-60	239 (190)	960 (351)	5.8 (0.4)
46	60-75	191 (82)	1054 (277)	5.7 (0.2)
46	75-90	159 (52)	989 (233)	5.7 (0.2)
		11 T/Ha Sludge Applied in 1976, 1977, and 1978		
21	0-15	1880 (568)	1777 (505)	6.8 (0.2)
21	15-30	891 (170)	1001 (231)	6.3 (0.1)
21	30-45	389 (118)	884 (187)	6.1 (0.5)
25	0-15	1335 (389)	1396 (307)	7.0 (0.1)
25	15-30	1060 (383)	1346 (423)	6.0 (0.2)
46	0-15	1384 (296)	1410 (477)	6.6 (0.3)
46	15-30	589 (167)	1153 (376)	6.0 (0.9)
46	30-45	414 (226)	1109 (442)	5.8 (0.7)
46	45-60	286 (226)	1110 (396)	5.8 (0.4)
46	60-75	143 (141)	1144 (350)	5.7 (0.6)
46	75-90	143 (95)	1130 (338)	5.9 (0.8)

*Standard Deviation

(Continued)

TABLE B-9. (Continued)

Week	Depth cm	Kjeldahl N ppm	Spec. Cond. umhos/cm	pH
22 T/Ha Sludge Applied in 1976				
21	0-15	1329 (194)*	996 (309)	6.5 (0.3)
21	15-30	794 (245)	864 (170)	6.1 (0.2)
21	30-45	632 (401)	595 (144)	5.9 (0.2)
25	0-15	1302 (571)	1149 (18)	6.9 (0.3)
25	15-30	865 (340)	1076 (60)	6.1 (0.4)
46	0-15	1129 (407)	1066 (231)	6.7 (0.2)
46	15-30	430 (175)	852 (125)	6.1 (0.4)
46	30-45	302 (131)	869 (122)	5.9 (0.4)
46	45-60	191 (82)	850 (202)	6.0 (0.3)
46	60-75	95 (0)	1022 (294)	5.8 (0.7)
46	75-90	64 (37)	1007 (179)	5.9 (0.2)
22 T/Ha Sludge Applied in 1976, 1977, and 1978				
21	0-15	1604 (292)	1986 (629)	6.8 (0.1)
21	15-30	989 (170)	1073 (161)	6.1 (0.0)
21	30-45	438 (162)	723 (49)	6.1 (0.2)
25	0-15	1335 (140)	1779 (739)	7.0 (0.1)
25	15-30	833 (344)	1854 (863)	6.0 (0.2)
46	0-15	1320 (563)	1295 (259)	6.9 (0.4)
46	15-30	382 (160)	983 (227)	6.0 (0.6)
46	30-45	207 (109)	909 (274)	6.0 (0.7)
46	45-60	143 (61)	931 (313)	5.9 (0.7)
46	60-75	95 (0)	1022 (294)	5.8 (0.7)
46	75-90	127 (110)	1038 (258)	5.6 (0.5)
54 T/Ha Sludge Applied in 1976				
21	0-15	1442 (170)	1192 (252)	6.9 (0.2)
21	15-30	778 (237)	1038 (422)	6.4 (0.4)
21	30-45	421 (202)	660 (162)	6.3 (0.1)
25	0-15	914 (221)	1104 (70)	7.2 (0.3)
25	15-30	1027 (625)	1018 (22)	6.4 (0.5)
46	0-15	1002 (309)	1091 (232)	7.0 (0.3)
46	15-30	493 (251)	785 (176)	6.6 (0.3)
46	30-45	255 (82)	856 (228)	6.3 (0.5)
46	45-60	191 (64)	886 (195)	6.3 (0.7)
46	60-75	143 (61)	946 (149)	6.2 (0.6)
46	75-90	127 (37)	1015 (169)	6.2 (0.6)

*Standard Deviation

(Continued)

TABLE B-9. (Continued)

Week	Depth	Kjeldahl N	Spec. Cond.	pH
	cm	ppm	umhos/cm	
		99 T/Ha Sludge Applied in 1976		
21	0-15	1086 (742)*	1454 (290)	6.9 (0.3)
21	15-30	697 (214)	961 (168)	6.2 (0.2)
21	30-45	567 (233)	963 (360)	5.9 (0.3)
25	0-15	1222 (277)	1326 (237)	7.0 (0.3)
25	15-30	962 (360)	1396 (608)	6.0 (0.4)
46	0-15	1018 (335)	1290 (517)	6.9 (0.4)
46	15-30	493 (413)	1050 (526)	6.3 (0.7)
46	30-45	350 (220)	964 (330)	6.1 (0.7)
46	45-60	286 (244)	1034 (320)	5.9 (0.5)
46	60-75	270 (80)	949 (211)	5.6 (0.3)
46	75-90	159 (73)	999 (713)	5.8 (0.5)
		99, 81 and 140 T/Ha Sludge Applied in 1976, 1977 and 1978, Respectively		
21	0-15	2204 (584)	3609 (621)	6.9 (0.3)
21	15-30	1102 (464)	1969 (730)	6.4 (0.4)
21	30-45	405 (62)	1118 (227)	6.1 (0.5)
25	0-15	1692 (586)	2513 (437)	7.2 (0.1)
25	15-30	995 (489)	2058 (349)	6.2 (0.5)
46	0-15	1432 (793)	2211 (984)	7.0 (0.3)
46	15-30	461 (204)	1675 (644)	6.4 (0.5)
46	30-45	445 (305)	1245 (303)	5.9 (0.3)
46	45-60	207 (131)	1138 (208)	5.7 (0.2)
46	60-75	223 (137)	1088 (160)	5.4 (0.3)
46	75-90	111 (32)	1163 (211)	5.5 (0.1)

*Standard Deviation

TABLE B-10. CALCIUM, MAGNESIUM, POTASSIUM, TOTAL P, AND CATION EXCHANGE CAPACITY OF SOIL SAMPLES FROM SLUDGE TREATED CORN PLOTS IN 1976

Week	Depth	Ca	Mg	K	Total P	CEC
	cm	----------	----------	ppm	----------	meq/100 g
			No Sludge Applied			
24	0-15	446 (170)*	47 (15)	16.8 (3.6)	191 (76)	3.5 (0.4)
	15-30	321 (171)	24 (18)	7.4 (2.2)	110 (21)	2.3 (0.6)
28	0-15	639 (352)	52 (23)	19.6 (3.2)	200 (66)	
	15-30	154 (114)	14 (11)	14.3 (8.8)	113 (46)	
45	0-15	454 (142)	58 (14)	21.6 (3.2)	225 (57)	3.6 (0.5)
	15-30	148 (56)	18 (7)	10.3 (2.7)	131 (32)	3.1 (0.4)
			11 T/Ha Sludge Applied			
24	0-15	539 (136)	47 (15)	16.8 (5.8)	228 (70)	3.9 (0.4)
	15-30	284 (118)	26 (14)	8.7 (5.3)	119 (30)	2.6 (0.6)
28	0-15	632 (316)	61 (34)	15.6 (5.9)	633 (860)	
	15-30	204 (68)	19 (9)	14.0 (8.0)	111 (24)	
45	0-15	577 (182)	61 (15)	22.7 (8.6)	230 (36)	4.1 (0.7)
	15-30	234 (74)	24 (11)	14.2 (7.9)	148 (38)	3.0 (1.3)
			22 T/Ha Sludge Applied			
24	0-15	723 (164)	48 (4)	12.3 (3.6)	266 (77)	3.8 (0.7)
	15-30	298 (101)	18 (7)	6.5 (0.7)	85 (21)	2.1 (0.3)
28	0-15	491 (120)	39 (8)	13.1 (4.1)	420 (220)	
	15-30	146 (20)	12 (2)	11.6 (2.6)	133 (25)	
45	0-15	571 (98)	64 (15)	17.9 (4.8)	294 (52)	4.1 (0.7)
	15-30	181 (24)	18 (6)	10.7 (1.5)	149 (46)	3.7 (1.0)

*Standard Deviation

(Continued)

TABLE B-10. (Continued)

Week	Depth	Ca	Mg	K	Total P	CEC
	cm	ppm				meq/100 g
			54 T/Ha Sludge Applied			
24	0-15	686 (289)*	50 (15)	11.0 (2.1)	294 (178)	3.9 (0.5)
	15-30	182 (115)	28 (12)	7.7 (2.8)	100 (27)	1.8 (0.4)
28	0-15	1275 (770)	57 (9)	20.6 (13.0)	783 (231)	
	15-30	116 (53)	12 (3)	12.2 (3.6)	113 (17)	
45	0-15	791 (186)	64 (7)	17.0 (5.6)	436 (107)	3.5 (0.5)
	15-30	213 (27)	29 (21)	10.9 (5.3)	130 (24)	3.3 (0.6)
			99 T/Ha Sludge Applied			
24	0-15	1413 (583)	107 (59)	14.1 (6.9)	463 (136)	4.3 (0.5)
	15-30	270 (98)	35 (16)	7.6 (1.6)	116 (12)	2.5 (0.6)
28	0-15	1060 (330)	73 (21)	26.6 (10.2)	1250 (777)	
	15-30	202 (68)	15 (9)	10.1 (4.0)	131 (10)	
45	0-15	990 (245)	66 (9)	18.1 (2.8)	613 (160)	4.2 (0.4)
	15-30	279 (90)	23 (7)	8.6 (2.5)	136 (16)	3.6 (1.0)

*Standard Deviation

TABLE B-11. CALCIUM, MAGNESIUM, SODIUM, POTASSIUM, BRAY P, TOTAL P, AND CATION EXCHANGE CAPACITY OF SOIL SAMPLES FROM SLUDGE TREATED CORN PLOTS IN 1977

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	----------	----------	----------	ppm	----------	----------	meq/100 g
				No Sludge Applied				
21	0-15	421 (116)*	53 (13)		59 (14)	47 (17)	426 (202)	2.6 (0.2)
21	15-30	210 (64)	16 (2)		22 (6)	36 (16)	211 (91)	1.6 (0.1)
26	0-15	579 (132)	78 (20)		57 (10)	45 (22)	149 (75)	
26	15-30	231 (118)	27 (11)		23 (5)	29 (14)	49 (48)	
47	0-15	379 (201)	39 (24)	97 (17)	20 (6)	8 (4)	153 (41)	2.0 (0.2)
47	15-30	158 (134)	18 (15)	82 (30)	11 (6)	6 (2)	53 (71)	1.4 (0.5)
47	30-45	131 (114)	16 (12)	75 (25)	10 (5)	6 (2)	53 (71)	
47	45-60	90 (52)	11 (6)	64 (11)	7 (2)	6 (2)	15 (25)	
47	60-75	179 (200)	18 (22)	74 (24)	12 (11)	8 (2)	40 (48)	
				11 T/Ha Sludge Applied in 1976				
21	0-15	586 (148)	61 (10)		61 (8)	46 (20)	574 (184)	2.4 (0.6)
21	15-30	175 (55)	17 (6)		22 (10)	34 (17)	236 (104)	1.6 (0.2)
26	0-15	1225 (1069)	86 (42)		58 (22)	59 (41)	449 (610)	
26	15-30	275 (59)	24 (5)		19 (6)	32 (15)	36 (29)	
47	0-15	740 (240)	69 (13)	99 (10)	36 (7)	8 (3)	341 (166)	2.2 (0.2)
47	15-30	358 (212)	25 (12)	80 (19)	14 (6)	6 (1)	40 (48)	1.2 (0.3)
47	30-45	175 (107)	14 (8)	67 (22)	9 (4)	5 (2)	40 (48)	
47	45-60	80 (35)	7 (2)	52 (10)	5 (2)	5 (2)	52 (72)	
47	60-75	57 (14)	5 (3)	56 (14)	5 (2)	6 (2)	15 (25)	

* Standard Deviation

(Continued)

TABLE B-11. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	ppm						meq/100 g
		11 T/Ha Sludge Applied in 1976 and 1977						
21	0-15	590 (238)*	59 (25)		135 (138)	60 (18)	445 (76)	2.8 (0.3)
21	15-30	237 (123)	19 (12)			42 (19)	236 (104)	1.8 (0.5)
26	0-15	912 (432)	86 (42)		50 (22)	69 (34)	211 (116)	
26	15-30	391 (159)	41 (16)			44 (24)	37 (29)	
47	0-15	870 (247)	61 (24)	92 (14)	30 (19)	12 (4)	504 (268)	2.2 (0.4)
47	15-30	478 (312)	29 (15)	68 (11)	15 (8)	8 (3)	191 (86)	1.4 (0.2)
47	30-45	222 (121)	15 (8)	64 (10)	13 (5)	7 (2)	115 (86)	
47	45-60	133 (95)	9 (5)	49 (10)	7 (4)	8 (3)	240 (251)	
47	60-75	75 (31)	6 (2)	43 (13)	6 (2)	8 (2)	78 (96)	
		22 T/Ha Sludge Applied in 1976						
21	0-15	498 (287)	51 (32)		49 (24)	68 (6)	974 (915)	2.0 (0.4)
21	15-30	234 (138)	21 (14)		25 (11)	53 (29)	261 (168)	2.0 (0.5)
26	0-15	742 (149)	76 (15)		48 (6)	70 (8)	261 (163)	
26	15-30	238 (28)	23 (2)		20 (3)	32 (5)	149 (243)	
47	0-15	681 (191)	63 (18)	100 (8)	32 (8)	11 (4)	291 (125)	2.0 (0.3)
47	15-30	222 (107)	22 (16)	83 (11)	18 (8)	6 (3)	78 (29)	1.4 (0.2)
47	30-45	154 (62)	15 (8)	72 (13)	12 (4)	6 (2)	27 (30)	
47	45-60	104 (30)	10 (4)	64 (15)	9 (2)	6 (3)	3 (0)	
47	60-75	73 (14)	6 (3)	62 (17)	6 (2)	6 (2)	15 (25)	

* Standard Deviation

(Continued)

TABLE B-11. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	ppm						meq/100 g
		22 T/Ha Sludge Applied in 1976 and 1977						
21	0-15	621 (101)*	59 (10)		50 (4)	77 (15)	736 (166)	2.0 (0.3)
21	15-30	155 (21)	13 (2)		14 (2)	43 (9)	199 (25)	1.4 (0.3)
26	0-15	807 (199)	71 (14)		45 (11)	71 (15)	224 (48)	
26	15-30	213 (20)	21 (2)		22 (4)	32 (12)	21 (27)	
47	0-15	804 (140)	60 (16)	96 (20)	28 (7)	14 (4)	479 (318)	2.2 (0.1)
47	15-30	161 (69)	16 (8)	70 (18)	12 (4)	7 (2)	66 (75)	1.2 (0.1)
47	30-45	102 (49)	10 (6)	58 (18)	8 (3)	8 (3)	128 (167)	
47	45-60	66 (28)	5 (3)	57 (20)	5 (1)	8 (2)	40 (26)	
47	60-75	65 (48)	5 (3)	62 (17)	4 (1)	7 (2)	15 (25)	
		54 T/Ha Sludge Applied in 1976						
21	0-15	686 (152)	49 (13)		55 (15)	87 (12)	949 (330)	2.4 (0.4)
21	15-30	207 (36)	14 (13)		17 (5)	45 (9)	274 (25)	1.2 (0.3)
26	0-15	1029 (322)	77 (18)		49 (8)	92 (10)	324 (250)	
26	15-30	253 (41)	21 (4)		22 (5)	34 (9)	49 (25)	
47	0-15	1041 (202)	63 (12)	96 (16)	29 (8)	17 (5)	804 (421)	2.4 (0.4)
47	15-30	281 (132)	19 (8)	65 (10)	10 (3)	8 (2)	91 (63)	1.2(0.4)
47	30-45	198 (116)	13 (4)	59 (11)	9 (2)	8 (2)	53 (58)	
47	45-60	145 (63)	11 (3)	56 (15)	8 (2)	7 (2)	28 (29)	
47	60-75	120 (57)	9 (5)	57 (19)	8 (3)	9 (1)	27 (30)	

*Standard Deviation

(Continued)

TABLE B-11. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	----------	----------	----------	ppm	----------	----------	meq/100 g
				99 T/Ha Sludge Applied in 1976				
21	0-15	1128 (259)*	61 (8)		56 (10)	110 (27)	1286 (119)	2.4 (0.4)
21	15-30	750 (1056)	14 (4)		15 (5)	46 (16)	199 (25)	1.6 (0.3)
26	0-15	1380 (467)	74 (16)		48 (9)	120 (21)	1086 (263)	
26	15-30	290 (124)	21 (8)		19 (7)	38 (20)	61 (41)	
47	0-15	1258 (251)	74 (11)	97 (5)	38 (5)	21 (6)	1130 (614)	2.6 (0.3)
47	15-30	261 (116)	16 (5)	62 (9)	10 (2)	8 (2)	178 (119)	1.6 (0.4)
47	30-45	161 (78)	10 (5)	59 (17)	10 (2)	6 (4)	78 (87)	
47	45-60	120 (33)	7 (3)	56 (13)	7 (3)	8 (6)	91 (75)	
47	60-75	65 (9)	4 (1)	49 (18)	6 (1)	6 (2)	40 (48)	
			99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively					
21	0-15	1494 (295)	87 (20)		56 (13)	119 (56)	574 (138)	3.2 (0.5)
21	15-30	286 (70)	20 (4)		18 (10)	39 (16)	236 (50)	2.0 (0.2)
26	0-15	1446 (405)	87 (12)		49 (10)	111 (81)	899 (438)	
26	15-30	305 (56)	27 (5)		21 (4)	43 (26)	86 (29)	
47	0-15	1451 (499)	61 (18)	109 (43)	29 (11)	16 (6)	1493 (602)	2.8 (0.7)
47	15-30	374 (194)	17 (8)	75 (31)	13 (5)	6 (1)	379 (492)	2.0 (0.5)
47	30-45	199 (60)	10 (2)	66 (28)	10 (4)	6 (2)	65 (126)	
47	45-60	160 (49)	9 (4)	55 (27)	6 (1)	6 (1)	65 (49)	
47	60-75	158 (84)	8 (5)	54 (23)	6 (3)	7 (2)	115 (104)	

*Standard Deviation

TABLE B-12. CALCIUM, MAGNESIUM, SODIUM, POTASSIUM, BRAY P, TOTAL P, AND CATION EXCHANGE CAPACITY OF SOIL SAMPLES FROM SLUDGE TREATED CORN PLOTS IN 1978

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	----------	----------	----------	ppm	----------	----------	meq/100 g
				No Sludge Applied				
21	0-15	818 (145)*	108 (26)	62 (20)	67 (15)	16 (12)	223 (94)	2.8 (0.8)
21	15-30	389 (89)	48 (17)	65 (16)	39 (13)	4 (1)	161 (41)	2.1 (0.7)
21	30-45	125 (114)	7 (12)	52 (24)	18 (9)	4 (2)	123 (48)	
25	0-15	1001 (154)	133 (29)	109 (23)	58 (14)	26 (17)	198 (48)	
25	15-30	346 (99)	45 (16)	78 (20)	31 (13)	5 (5)	148 (48)	
46	0-15	827 (264)	103 (29)	109 (23)	58 (14)	26 (17)	198 (48)	
46	15-30	223 (172)	34 (27)	104 (41)	14 (5)	3 (2)	181 (66)	1.8 (0.6)
46	30-45	100 (52)	17 (13)	88 (33)	11 (2)	3 (1)	119 (43)	
46	45-60	62 (20)	14 (10)	86 (18)	9 (2)	4 (3)	94 (38)	
46	60-75	42 (22)	13 (10)	78 (9)	7 (1)	6 (4)	82 (32)	
46	75-90	40 (33)	12 (9)	85 (18)	7 (3)	8 (5)	106 (55)	
				11 T/Ha Sludge Applied in 1976				
21	0-15	1000 (299)	106 (23)	66 (9)	69 (7)	34 (38)	983 (1446)	2.9 (0.4)
21	15-30	581 (384)	45 (32)	58 (11)	35 (12)	18 (20)	198 (75)	2.1 (0.4)
21	30-45	276 (215)	12 (17)	51 (10)	16 (6)	7 (7)	136 (29)	
25	0-15	1129 (502)	120 (49)	113 (27)	61 (20)	46 (31)	285 (50)	
25	15-30	512 (228)	59 (38)	109 (32)	35 (16)	9 (10)	186 (29)	
46	0-15	970 (448)	81 (38)	112 (43)	30 (8)	48 (56)	481 (514)	2.2 (0.5)
46	15-30	424 (331)	38 (30)	87 (28)	17 (8)	13 (12)	181 (52)	1.1 (0.4)
46	30-45	196 (150)	21 (15)	82 (22)	10 (2)	5 (5)	106 (37)	
46	45-60	90 (48)	12 (7)	78 (18)	9 (4)	7 (6)	106 (37)	
46	60-75	93 (44)	11 (6)	81 (10)	8 (2)	5 (5)	94 (24)	
46	75-90	68 (21)	9 (4)	80 (20)	7 (3)	7 (6)	82 (32)	

*Standard Deviation

(Continued)

TABLE B-12. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	ppm						meq/100 g
				11 T/Ha Sludge Applied in 1976, 1977, and 1978				
21	0-15	1290 (383)*	110 (38)	57 (20)	71 (26)	80 (44)	634 (221)	2.6 (0.6)
21	15-30	532 (137)	46 (16)	50 (16)	37 (8)	26 (17)	260 (41)	1.9 (0.4)
21	30-45	194 (54)	5 (6)	41 (8)	16 (4)	12 (5)	111 (0)	
25	0-15	1445 (252)	126 (39)	104 (26)	62 (20)	68 (39)	447 (25)	
25	15-30	716 (295)	69 (35)	95 (34)	41 (19)	13 (12)	211 (81)	
46	0-15	1038 (208)	88 (29)	121 (50)	33 (11)	53 (54)	531 (331)	2.4 (0.3)
46	15-30	404 (300)	32 (15)	102 (27)	17 (6)	11 (8)	206 (38)	1.7 (0.5)
46	30-45	208 (196)	19 (10)	89 (9)	11 (3)	3 (2)	156 (62)	
46	45-60	141 (78)	14 (5)	86 (13)	8 (2)	3 (1)	131 (42)	
46	60-75	92 (30)	10 (5)	83 (13)	8 (3)	4 (1)	119 (43)	
46	75-90	76 (39)	9 (4)	89 (11)	7 (2)	8 (5)	82 (32)	
				22 T/Ha Sludge Applied in 1976				
21	0-15	992 (224)	109 (28)	57 (16)	67 (12)	55 (31)	435 (150)	2.8 (0.7)
21	15-30	387 (141)	35 (18)	56 (13)	37 (9)	16 (12)	223 (25)	1.8 (0.5)
21	30-45	146 (42)	3 (4)	44 (10)	20 (7)	5 (3)	136 (29)	
25	0-15	1273 (359)	137 (46)	107 (13)	59 (12)	47 (40)	535 (259)	
25	15-30	396 (114)	43 (14)	75 (9)	31 (5)	6 (6)	198 (48)	
46	0-15	918 (301)	108 (44)	128 (47)	34 (12)	32 (18)	287 (126)	2.6 (1.0)
46	15-30	206 (95)	30 (11)	90 (14)	13 (4)	7 (6)	150 (54)	1.4 (1.0)
46	30-45	101 (32)	18 (7)	91 (6)	10 (2)	5 (4)	100 (54)	
46	45-60	74 (25)	13 (8)	88 (10)	9 (2)	4 (2)	75 (36)	
46	60-75	59 (12)	11 (7)	85 (5)	10 (5)	7 (1)	63 (15)	
46	75-90	38 (9)	9 (8)	81 (7)	7 (1)	9 (0)	63 (15)	

*Standard Deviation

(Continued)

TABLE B-12. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	ppm						meq/100 g
		22 T/Ha Sludge Applied in 1976, 1977, and 1978						
21	0-15	1286 (132)*	103 (19)	52 (8)	63 (8)	91 (18)	734 (96)	2.8 (0.7)
21	15-30	492 (64)	45 (12)	53 (17)	38 (5)	16 (7)	335 (119)	1.9 (0.3)
21	30-45	241 (132)	16 (17)	45 (12)	20 (8)	9 (2)		
25	0-15	1536 (268)	110 (21)	95 (8)	55 (7)	72 (46)	597 (110)	
25	15-30	398 (53)	34 (6)	63 (6)	29 (5)	6 (5)	211 (41)	
46	0-15	1117 (375)	81 (27)	115 (35)	27 (11)	61 (38)	798 (680)	2.4 (0.4)
46	15-30	154 (89)	22 (16)	91 (16)	13 (4)	7 (4)	150 (54)	0.8 (0.5)
46	30-45	99 (21)	15 (4)	81 (5)	9 (2)	6 (3)	88 (60)	
46	45-60	95 (60)	15 (8)	85 (5)	9 (1)	10 (8)	88 (60)	
46	60-75	69 (29)	12 (7)	86 (6)	7 (2)	7 (3)	75 (36)	
46	75-90	56 (36)	11 (6)	82 (10)	7 (1)	9 (2)	75 (36)	
		54 T/Ha Sludge Applied in 1976						
21	0-15	1284 (293)	95 (16)	50 (8)	62 (9)	121 (41)	622 (85)	2.7 (0.4)
21	15-30	586 (146)	41 (14)	46 (3)	33 (7)	35 (16)	248 (48)	1.5 (0.3)
21	30-45	213 (86)	6 (5)	46 (14)	16 (5)	8 (2)	161 (70)	
25	0-15	1626 (388)	122 (23)	99 (10)	53 (6)	111 (19)	647 (239)	
25	15-30	422 (138)	44 (20)	71 (11)	31 (10)	15 (6)	198 (48)	
46	0-15	1121 (475)	97 (26)	111 (24)	26 (10)	48 (22)	380 (184)	2.2 (0.6)
46	15-30	758 (94)	39 (18)	98 (23)	12 (2)	9 (9)	169 (52)	1.2 (0.7)
46	30-45	175 (138)	23 (18)	84 (12)	9 (3)	5 (3)	106 (38)	
46	45-60	137 (66)	18 (12)	83 (13)	9 (3)	6 (7)	106 (24)	
46	60-75	78 (42)	14 (11)	78 (18)	7 (2)	8 (8)	119 (13)	
46	75-90	81 (68)	14 (9)	71 (18)	6 (1)	13 (2)	94 (24)	

*Standard Deviation

(Continued)

TABLE B-12. (Continued)

Week	Depth	Ca	Mg	Na	K	Bray P	Total P	CEC
	cm	----------	----------	----------	ppm	----------	----------	meq/100 g
				99 T/Ha Sludge Applied in 1976				
21	0-15	1297 (321)*	98 (32)	61 (19)	61 (16)	104 (72)	1718 (1908)	2.9 (0.5)
21	15-30	538 (133)	39 (8)	49 (17)	31 (6)	28 (23)	348 (205)	1.9 (0.7)
21	30-45	213 (90)	6 (8)	47 (11)	16 (4)	15 (15)	136 (29)	
25	0-15	1627 (489)	121 (16)	109 (14)	52 (7)	117 (87)	846 (433)	
25	15-30	422 (138)	35 (8)	77 (24)	27 (4)	11 (8)	177 (58)	
46	0-15	1058 (549)	77 (42)	109 (35)	21 (6)	39 (40)	381 (206)	2.3 (0.5)
46	15-30	250 (194)	24 (16)	84 (23)	10 (2)	7 (7)	169 (82)	1.2 (1.2)
46	30-45	156 (64)	18 (8)	82 (9)	11 (1)	8 (11)	119 (43)	
46	45-60	137 (66)	18 (12)	83 (13)	9 (3)	6 (7)	106 (24)	
46	60-75	78 (42)	14 (11)	78 (18)	7 (2)	8 (8)	119 (13)	
46	75-90	74 (33)	14 (8)	79 (18)	8 (3)	11 (9)	106 (38)	
		99, 81 and 140 T/Ha Sludge Applied in 1976, 1977 and 1978, Respectively						
21	0-15	2365 (313)	117 (33)	77 (14)	66 (17)	205 (38)	2229 (484)	3.4 (0.9)
21	15-30	893 (432)	43 (24)	54 (13)	32 (17)	42 (44)	460 (318)	2.2 (0.8)
21	30-45	346 (92)	11 (8)	41 (5)	15 (5)	11 (9)	173 (63)	
25	0-15	3189 (226)	144 (34)	116 (26)	66 (18)	197 (85)	1993 (667)	
25	15-30	758 (94)	47 (10)	69 (11)	28 (7)	17 (14)	298 (25)	
46	0-15	1678 (670)	83 (39)	111 (51)	31 (15)	52 (26)	742 (564)	3.0 (1.5)
46	15-30	344 (240)	30 (12)	79 (29)	14 (6)	13 (13)	286 (116)	1.1 (0.4)
46	30-45	323 (253)	50 (40)	85 (37)	14 (12)	5 (3)	181 (72)	
46	45-60	137 (74)	18 (10)	74 (13)	9 (3)	7 (7)	131 (31)	
46	60-75	74 (20)	14 (10)	69 (15)	7 (3)	6 (5)	119 (13)	
46	75-90	81 (68)	14 (9)	71 (18)	6 (1)	13 (2)	94 (24)	

*Standard Deviation

TABLE B-13. HEAVY METAL CONTENT OF PLANT SAMPLES FROM THE SLUDGE TREATMENTS IN 1976

Treatment	Component	Week	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
			ppm								
No Sludge	Corn tissue	27	590 (403)	70 (14)	13 (1.4)	90 (34)	0.2 (0.3)	1.5 (1.9)	0.1 (0.3)	11 (12)	ND**
		32	125 (24)	37 (7)	10 (3.1)	105 (38)	ND	1.5 (1.7)	ND	ND	ND
		39	120 (14)	71 (6)	6 (1.6)	50 (8)	1.5 (0.6)	ND	0.2 (0.5)	ND	ND
	grain	39	38 (13)	4.9 (0.9)	ND	20 (1)	ND	ND	ND	ND	ND
		45	26 (6)	6.1 (1.3)	ND	40 (5)	ND	ND	ND	ND	ND
11 T/Ha Sludge	tissue	27	750 (953)	80 (18)	14 (2.6)	130 (19)	1.5 (1.1)	4.8 (5.7)	0.3 (0.3)	1.5 (3)	ND
		32	140 (35)	48 (12)	14 (4.6)	157 (57)	ND	5.0 (3.5)	0.4 (0.5)	ND	ND
		39	120 (7)	74 (13)	8 (2.6)	82 (15)	1.8 (1.5)	ND	0.8 (1.0)	ND	ND
	grain	39	35 (6)	3.6 (2.4)	ND	20 (1)	ND	ND	ND	ND	ND
		45	35 (11)	5.6 (1.2)	ND	44 (5)	ND	ND	ND	ND	ND
22 T/Ha Sludge	tissue	27	595 (406)	77 (22)	14 (0.8)	176 (41)	1.5 (1.9)	3.5 (3.4)	0.4 (0.5)	8 (9)	ND
		32	145 (27)	67 (19)	16 (3.3)	178 (60)	0.8 (1.0)	4.0 (4.9)	0.4 (0.5)	ND	ND
		39	130 (8)	85 (22)	14 (7.1)	140 (14)	1.0 (1.4)	ND	0.2 (0.5)	ND	ND
	grain	39	42 (15)	5.1 (0.7)	ND	24 (3)	ND	ND	ND	ND	ND
		45	28 (5)	6.0 (1.6)	ND	49 (5)	ND	ND	ND	ND	ND
55 T/Ha Sludge	tissue	27	225 (30)	90 (23)	15 (2.1)	253 (57)	2.7 (2.7)	2.5 (3.0)	0.8 (0.3)	8 (4)	ND
		32	160 (46)	72 (24)	18 (2.6)	195 (16)	0.4 (0.9)	3.0 (3.8)	0.6 (0.4)	ND	ND
		39	120 (20)	74 (22)	9 (3.5)	160 (45)	2.3 (0.5)	ND	0.8 (1.0)	ND	ND
	grain	39	48 (22)	4.5 (0.2)	ND	26 (2)	ND	ND	ND	ND	ND
		45	33 (3)	6.5 (1.3)	ND	54 (2)	ND	ND	ND	ND	ND
99 T/Ha Sludge	tissue	27	1150 (695)	100 (17)	17 (4.1)	310 (77)	1.8 (1.1)	9.0 (6.2)	0.9 (0.6)	15 (3)	ND
		32	135 (26)	84 (14)	17 (3.5)	349 (82)	0.4 (0.9)	3.3 (2.5)	0.8 (0.6)	ND	ND
		39	130 (17)	90 (17)	10 (1.7)	261 (13)	0.8 (1.0)	ND	0.5 (1.0)	ND	ND
	grain	39	44 (2)	4.3 (0.7)	ND	28 (2)	ND	ND	ND	ND	ND
		45	50 (28)	5.6 (1.1)	ND	60 (10)	ND	ND	ND	ND	ND

** Not Detectable

TABLE B-14. NUTRIENT CONTENT OF PLANT TISSUE AND GRAIN SAMPLES FROM THE SLUDGE TREATMENTS IN 1976

Treatment	Component	Week	Ca	Mg	Total K	Total P	Total N
			ppm				
No Sludge	Corn tissue	27	4100 (367)*	2500 (243)	48700 (1500)	2000 (257)	27800 (4210)
		32	3000 (466)	1500 (216)	17100 (1140)	2900 (202)	23600 (2140)
		39	2900 (567)	2100 (300)	14300 (1320)	700 (121)	7500 (818)
	grain	39	tr**	300 (21)	4300 (514)	3000 (342)	12300 (1650)
		45	tr	600 (62)	4600 (260)	3100 (303)	13400 (1030)
11 T/Ha Sludge	tissue	27	4700 (338)	2500 (107)	49200 (8250)	2300 (244)	29900 (2730)
		32	4300 (437)	2000 (495)	15200 (1690)	3000 (349)	25000 (5940)
		39	3700 (338)	2400 (293)	13000 (2490)	700 (209)	7800 (1800)
	grain	39	tr	600 (65)	3600 (160)	2800 (334)	13000 (714)
		45	tr	600 (26)	4200 (264)	3300 (301)	13800 (3320)
22 T/Ha Sludge	tissue	27	5700 (866)	2600 (334)	40100 (6200)	2600 (203)	28300 (4570)
		32	5100 (590)	2400 (542)	13000 (1100)	3100 (201)	24900 (3380)
		39	4500 (556)	2900 (334)	12700 (2430)	800 (155)	10200 (804)
	grain	39	tr	500 (62)	3500 (343)	2800 (286)	11500 (3010)
		45	tr	600 (26)	4000 (131)	3100 (231)	16500 (2060)
54 T/Ha Sludge	tissue	27	6800 (526)	3200 (603)	44700 (11250)	2800 (116)	29400 (6910)
		32	5900 (512)	3000 (354)	12900 (789)	3500 (418)	25300 (3690)
		39	5000 (505)	3100 (318)	13600 (1150)	900 (120)	9500 (2040)
	grain	39	tr	600 (95)	3500 (163)	2900 (326)	14100 (1520)
		45	tr	600 (54)	4000 (212)	3500 (201)	15300 (1930)
99 T/Ha Sludge	tissue	27	7700 (1160)	3600 (512)	42600 (780)	2900 (511)	25200 (6080)
		32	7600 (570)	3900 (544)	9400 (1760)	3400 (266)	30600 (2540)
		39	6100 (389)	3800 (363)	10200 (350)	1000 (104)	10000 (1680)
	grain	39	tr	600 (21)	3700 (346)	3100 (24)	13600 (911)
		42	tr	600 (131)	3800 (674)	3300 (553)	15500 (1280)

*Standard Deviation

**Trace was from 20 to 50 ppm

TABLE B-15. HEAVY METAL CONTENT OF PLANT TISSUE SAMPLES FROM THE SLUDGE TREATMENTS IN 1977

Treatment	Week	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
		ppm								
No Sludge Applied	22	117 (3)*	31 (5)	13 (3)	35 (3)	12 (1)	7 (5)	ND**	7 (3)	1.4 (1.5)
	31	165 (32)	47 (8)	15 (2)	81 (8)	12 (1)	ND	ND	ND	4.9 (2.5)
	40	112 (30)	49 (9)	6 (1)	44 (2)	12 (1)	8 (7)	ND	10 (8)	4.5 (4.3)
11 T/Ha Sludge Applied in 1976	22	131 (15)	36 (18)	22 (16)	116 (141)	12 (1)	6 (8)	3 (3)	4 (2)	1.6 (1.3)
	31	162 (20)	37 (16)	14 (3)	96 (50)	11 (1)	ND	ND	ND	2.3 (1.2)
	40	100 (15)	33 (7)	9 (3)	56 (6)	12 (1)	7 (5)	ND	6 (5)	4.0 (4.0)
11 T/Ha Sludge Applied in 1976 and 1977	22	123 (8)	71 (70)	25 (23)	116 (90)	12 (1)	4 (3)	ND	6 (4)	1.5 (0.6)
	31	157 (15)	45 (7)	16 (2)	104 (25)	12 (0)	ND	ND	5 (8)	2.2 (1.3)
	40	101 (39)	39 (6)	8 (2)	86 (27)	13 (1)	7 (2)	ND	4 (4)	3.7 (3.4)
22 T/Ha Sludge Applied in 1976	22	122 (7)	30 (5)	16 (4)	59 (6)	11 (0)	9 (3)	ND	14 (13)	1.0 (0.5)
	31	156 (11)	44 (6)	15 (1)	169 (31)	13 (0)	ND	ND	8 (14)	2.4 (1.1)
	40	85 (13)	37 (10)	8 (1)	79 (7)	11 (1)	10 (8)	ND	6 (6)	2.1 (2.0)
22 T/Ha Sludge Applied in 1976 and 1977	22	118 (4)	36 (5)	15 (1)	106 (29)	12 (0)	6 (4)	ND	6 (4)	1.3 (0.6)
	31	167 (51)	43 (4)	15 (3)	130 (88)	12 (2)	9 (14)	ND	ND	4.8 (1.6)
	40	92 (26)	41 (7)	8 (2)	173 (21)	13 (1)	14 (9)	ND	8 (7)	4.0 (4.9)
54 T/Ha Sludge Applied in 1976	22	122 (16)	28 (7)	16 (1)	66 (6)	12 (1)	6 (2)	ND	6 (1)	1.3 (0.6)
	31	147 (37)	30 (8)	17 (4)	154 (15)	13 (1)	4 (5)	ND	ND	5.7 (0.0)
	40	98 (22)	28 (8)	9 (1)	85 (16)	13 (1)	7 (5)	ND	8 (7)	4.0 (4.0)
99 T/Ha Sludge Applied in 1976	22	132 (24)	32 (9)	14 (2)	94 (11)	12 (1)	6 (2)	ND	9 (6)	1.0 (0.6)
	31	154 (26)	42 (5)	18 (3)	127 (71)	14 (2)	ND	ND	ND	3.1 (2.0)
	40	67 (12)	35 (9)	10 (1)	176 (26)	14 (2)	8 (7)	ND	12 (4)	2.7 (3.9)
99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively	22	130 (19)	43 (17)	20 (10)	134 (17)	12 (1)	4 (3)	ND	5 (2)	1.0 (0.5)
	31	216 (40)	54 (16)	19 (4)	246 (54)	14 (2)	ND	ND	ND	4.9 (2.5)
	40	96 (17)	39 (4)	11 (4)	337 (20)	13 (1)	10 (8)	ND	12 (4)	3.1 (2.8)

*Standard Deviation **Not Detectable

TABLE B-16. HEAVY METAL CONTENT OF PLANT TISSUE SAMPLES FROM THE SLUDGE TREATMENTS IN 1978

Treatment	Week	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
		ppm								
No Sludge Applied	28	112 (40)*	7 (4)	3 (1)	36 (10)	13 (4)	ND**	ND	ND	ND
	30	100 (13)	22 (4)	7 (3)	29 (10)	11 (3)	ND	ND	ND	0.9 (0.4)
11 T/Ha Sludge Applied in 1976	28	110 (22)	9 (4)	4 (2)	39 (5)	12 (1)	ND	ND	ND	ND
	30	112 (32)	22 (3)	9 (2)	26 (1)	13 (3)	ND	ND	ND	ND
11 T/Ha Sludge Applied in 1976, 1977 and 1978	28	100 (8)	15 (7)	3 (1)	49 (12)	13 (4)	ND	ND	ND	ND
	30	138 (6)	23 (6)	11 (2)	34 (3)	12 (1)	ND	ND	ND	ND
22 T/Ha Sludge Applied in 1976	28	89 (14)	15 (9)	3 (1)	39 (2)	14 (4)	ND	ND	ND	1.2 (0.8)
	30	185 (194)	24 (5)	8 (2)	31 (1)	14 (4)	ND	ND	ND	0.8 (0.2)
22 T/Ha Sludge Applied in 1976, 1977 and 1978	28	94 (18)	13 (9)	4 (1)	65 (7)	16 (2)	ND	ND	ND	1.1 (0.5)
	30	95 (7)	28 (5)	9 (2)	45 (9)	14 (5)	ND	ND	ND	ND
54 T/Ha Sludge Applied in 1976	28	92 (14)	6 (3)	4 (1)	41 (4)	15 (4)	ND	ND	ND	ND
	30	97 (4)	20 (4)	9 (3)	31 (6)	14 (3)	ND	ND	ND	ND
99 T/Ha Sludge Applied in 1976	28	96 (28)	10 (8)	4 (2)	61 (23)	17 (4)	ND	ND	ND	1.0 (0.6)
	30	101 (8)	23 (2)	10 (1)	35 (8)	13 (4)	ND	ND	ND	ND
99, 81, and 140 T/Ha Sludge Applied in 1976, 1977 and 1978, Respectively	28	145 (123)	11 (11)	8 (5)	86 (21)	20 (13)	ND	ND	ND	1.0 (0.4)
	30	109 (30)	27 (5)	12 (4)	97 (34)	11 (4)	ND	ND	ND	ND

*Standard Deviation **Not Detectable

TABLE B-17. HEAVY METAL CONTENT OF GRAIN SAMPLES FROM THE SLUDGE TREATMENTS IN 1977

Treatment	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	ppm								
No Sludge Applied	20 (10)*	3 (0)	3 (1)	25 (4)	12 (3)	ND**	15 (5)	8 (4)	1.0 (0.6)
11 T/Ha Sludge Applied in 1976	8 (4)	3 (1)	3 (2)	28 (4)	13 (3)	ND	12 (9)	8 (4)	0.8 (0.1)
11 T/Ha Sludge Applied in 1976 and 1977	12 (4)	4 (1)	4 (1)	34 (4)	14 (2)	ND	16 (5)	10 (11)	1.4 (0.7)
22 T/Ha Sludge Applied in 1976	13 (7)	4 (1)	4 (1)	32 (7)	14 (4)	ND	16 (3)	9 (3)	0.8 (0.1)
22 T/Ha Sludge Applied in 1976 and 1977	18 (12)	5 (1)	4 (2)	36 (6)	12 (1)	ND	16 (3)	9 (3)	ND
54 T/Ha Sludge Applied in 1976	15 (5)	4 (1)	3 (1)	32 (4)	12 (3)	ND	15 (5)	11 (5)	0.8 (0.1)
99 T/Ha Sludge Applied in 1976	10 (8)	4 (1)	4 (1)	39 (9)	14 (2)	ND	13 (4)	10 (3)	0.8 (0.1)
99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively	17 (9)	4 (2)	5 (3)	44 (4)	16 (2)	ND	11 (7)	16 (14)	0.8 (0.1)

*Standard Deviation **Not Detectable

TABLE B-18. HEAVY METAL CONTENT OF GRAIN SAMPLES FROM THE SLUDGE TREATMENTS IN 1978

Treatment	Fe	Mn	Cu	Zn	Cr	Pb	Cd	Ni	Hg
	ppm								
No Sludge Applied	38 (5)*	3 (1)	3 (0)	24 (3)	13 (2)	ND**	ND	ND	ND
11 T/Ha Sludge Applied in 1976	32 (8)	3 (1)	3 (0)	24 (5)	10 (3)	ND	ND	ND	1.8 (2.3)
11 T/Ha Sludge Applied in 1976, 1977, and 1978	34 (4)	3 (1)	3 (1)	34 (6)	11 (2)	ND	ND	ND	ND
22 T/Ha Sludge Applied in 1976	40 (5)	3 (0)	4 (1)	28 (4)	12 (2)	ND	ND	ND	ND
22 T/Ha Sludge Applied in 1976, 1977, and 1978	41 (4)	3 (1)	4 (2)	42 (13)	10 (2)	ND	ND	ND	ND
54 T/Ha Sludge Applied in 1976	33 (3)	3 (0)	4 (2)	30 (9)	11 (3)	ND	ND	ND	ND
99 T/Ha Sludge Applied in 1976	34 (4)	3 (1)	3 (0)	33 (12)	11 (2)	ND	ND	ND	ND
99, 81 and 140 T/Ha Sludge Applied in 1976, 1977, and 1978, Respectively	36 (4)	4 (1)	3 (0)	52 (10)	10 (1)	ND	ND	ND	3.2 (5)

*Standard Deviation **Not Detectable

TABLE B-19. NUTRIENT CONTENT OF PLANT TISSUE SAMPLES FROM THE SLUDGE TREATMENTS IN 1977

Treatment	Week	Ca	Mg	K	Total P	Total N
		ppm				
No Sludge Applied	22	3837 (394)*	1895 (94)	16227 (3481)	2980 (270)	33638 (1903)
	31	4114 (178)	3497 (338)	36971 (8350)	3329 (491)	28683 (1198)
	40	3095 (90)	1930 (151)	10588 (697)	643 (92)	6598 (3717)
11 T/Ha Sludge Applied in 1976	22	5457 (1774)	2167 (501)	22797 (15328)	3160 (140)	32510 (1623)
	31	5194 (854)	3079 (1101)	28215 (7493)	3396 (255)	28845 (7426)
	40	3857 (251)	1884 (104)	10238 (2547)	818 (272)	7064 (2978)
11 T/Ha Sludge Applied in 1976 and 1977	22	6291 (2022)	2139 (281)	18157 (17818)	3483 (482)	33714 (1362)
	31	5725 (691)	3328 (960)	24701 (7266)	3629 (164)	31546 (4104)
	40	4094 (184)	1938 (143)	9541 (1395)	887 (114)	8509 (1844)
22 T/Ha Sludge Applied in 1976	22	4644 (257)	1892 (116)	15231 (4900)	3420 (120)	34518 (964)
	31	6258 (646)	4021 (714)	38283 (7940)	3979 (297)	28278 (3792)
	40	3949 (289)	1787 (130)	9890 (1757)	805 (143)	8428 (307)
22 T/Ha Sludge Applied in 1976 and 1977	22	6176 (248)	2119 (72)	10260 (1672)	3410 (30)	35648 (1376)
	31	5743 (669)	4064 (505)	29092 (7897)	3754 (425)	29169 (2337)
	40	4673 (218)	2136 (83)	7096 (1339)	749 (244)	5635 (3075)
54 T/Ha Sludge Applied in 1976	22	5318 (623)	1902 (128)	10592 (2169)	3510 (110)	35410 (2063)
	31	6156 (266)	4106 (1118)	28438 (6516)	4204 (424)	31114 (4584)
	40	4716 (291)	1971 (169)	10936 (1395)	893 (105)	7786 (1240)
99 T/Ha Sludge Applied in 1976	22	6603 (335)	2008 (164)	10258 (3812)	3342 (92)	36049 (1305)
	31	6652 (1631)	4380 (1165)	30411 (6172)	4116 (494)	27954 (2488)
	40	5385 (333)	1964 (178)	10936 (1800)	818 (92)	6277 (3682)
99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively	22	7737 (409)	1595 (1067)	9260 (4970)	3392 (105)	32758 (3399)
	31	9126 (2551)	5074 (2057)	28770 (3464)	3985 (416)	29493 (592)
	40	5942 (157)	2089 (187)	9538 (3510)	874 (133)	8428 (959)

*Standard Deviation

TABLE B-20. NUTRIENT CONTENT OF PLANT TISSUE SAMPLES FROM THE SLUDGE TREATMENTS IN 1978

Treatment	Week	Ca	Mg	K	Total P	Total N
		ppm				
No Sludge Applied	28	2652 (151)*	1560 (210)	32030 (7520)	2086 (118)	22218 (5238)
	30	3113 (256)	1340 (230)	19760 (1000)	2513 (120)	25070 (5126)
11 T/Ha Sludge Applied in 1976	28	2678 (189)	1440 (390)	31370 (5500)	2332 (176)	19566 (2468)
	30	2703 (226)	1070 (140)	21470 (710)	2710 (193)	25889 (1680)
11 T/Ha Sludge Applied in 1976, 1977, and 1978	28	2897 (265)	1260 (40)	31890 (1640)	2644 (132)	19036 (1443)
	30	3361 (345)	960 (160)	20820 (1150)	2847 (50)	26672 (559)
22 T/Ha Sludge Applied in 1976	28	3000 (630)	1420 (430)	29200 (7250)	2588 (182)	17737 (1517)
	30	3455 (731)	1120 (170)	20500 (1140)	2872 (73)	25929 (1305)
22 T/Ha Sludge Applied in 1976, 1977, and 1978	28	2964 (274)	1510 (270)	21930 (10180)	2538 (157)	18373 (1043)
	30	3306 (141)	1140 (200)	20090 (450)	2890 (51)	27997 (946)
54 T/Ha Sludge Applied in 1976	28	3070 (398)	1380 (320)	22340 (10100)	2550 (131)	20362 (1110)
	30	3255 (186)	1280 (120)	20370 (1060)	2803 (62)	27480 (272)
99 T/Ha Sludge Applied in 1976	28	2962 (346)	1340 (220)	22000 (4560)	2419 (221)	17737 (3075)
	30	3219 (350)	1330 (260)	20500 (1220)	2766 (244)	27082 (2217)
99, 81 and 140 T/Ha Sludge Applied in 1976, 1977, and 1978, Respectively	28	3227 (208)	1510 (620)	23890 (7750)	2588 (252)	20203 (3339)
	30	4421 (415)	1650 (660)	17720 (4060)	2747 (277)	28872 (1414)

*Standard Deviation

TABLE B-21. NUTRIENT CONTENT OF GRAIN SAMPLES FROM THE SLUDGE TREATMENTS IN 1977

Treatment	Ca	Mg	K	Total P	Total N
	ppm				
No Sludge Applied	148 (49)*	1141 (148)	2832 (709)	2430 (698)	14288 (1065)
11 T/Ha Sludge Applied in 1976	120 (43)	1227 (151)	2969 (275)	3098 (470)	14369 (1061)
11 T/Ha Sludge Applied in 1976 and 1977	183 (68)	1344 (120)	3107 (0)	3017 (693)	15252 (669)
22 T/Ha Sludge Applied in 1976	156 (50)	1356 (317)	3243 (1039)	3061 (352)	15332 (549)
22 T/Ha Sludge Applied in 1976 and 1977	177 (59)	1343 (219)	2969 (526)	2398 (581)	17901 (4581)
54 T/Ha Sludge Applied in 1976	169 (53)	1360 (142)	3107 (0)	2861 (507)	15252 (414)
99 T/Ha Sludge Applied in 1976	172 (48)	1359 (304)	3106 (776)	2467 (372)	18141 (5894)
99 and 81 T/Ha Sludge Applied in 1976 and 1977, Respectively	221 (82)	1392 (209)	3106 (776)	3136 (450)	16536 (414)

*Standard Deviation

TABLE B-22. NUTRIENT CONTENT OF GRAIN SAMPLES FROM THE SLUDGE TREATMENTS IN 1978

Treatment	Ca	Mg	K	Total P	Total N
			ppm		
No Sludge Applied	55 (18)*	1123 (102)	3380 (333)	2573 (210)	13704 (1815)
11 T/Ha Sludge Applied in 1976	50 (15)	1090 (121)	3284 (332)	2635 (434)	13983 (2031)
11 T/Ha Sludge Applied in 1976, 1977, and 1978	47 (13)	1192 (65)	3478 (119)	2965 (285)	14778 (1726)
22 T/Ha Sludge Applied in 1976	52 (8)	1271 (98)	3573 (287)	3065 (245)	14619 (1378)
22 T/Ha Sludge Applied in 1976, 1977, and 1978	60 (10)	1192 (92)	3230 (146)	2803 (201)	15852 (794)
54 T/Ha Sludge Applied in 1976	57 (13)	1150 (183)	3173 (421)	2809 (341)	14659 (1135)
99 T/Ha Sludge Applied in 1976	63 (19)	1170 (133)	3382 (198)	2697 (345)	15375 (1275)
99, 81 and 140 T/Ha Sludge Applied in 1976, 1977, and 1978, Respectively	78 (25)	1109 (122)	3035 (305)	2610 (284)	15216 (2277)

*Standard Deviation